

Federal Plan for Marine Environmental Prediction

FISCAL YEAR 1972

FEDERAL COORDINATOR FOR
MARINE ENVIRONMENTAL
PREDICTION



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

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FEDERAL COORDINATOR FOR
MARINE ENVIRONMENTAL
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WASHINGTON, D.C.
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PREFACE

This Federal Plan is the first to be developed by the Federal Coordinator for Marine Environmental Prediction. The Plan is being published to provide the Executive Branch with a coordinated, overall summary of Government Marine Environmental Prediction (MAREP) Services and of relevant research and development programs to improve services in MAREP. Such Services include timely predictions of the states of the ocean, its living resources, and the adjacent overlying atmosphere which affect man's activities, interests, and well-being; also included are forecasts, warnings, and data summaries and studies issued for the benefit of commerce, navigation, fisheries, offshore drilling and mining, recreation, defense, and other marine activities.

On November 7, 1969, the Vice President, as Chairman of the Marine Science Council, assigned a lead agency role to the Secretary of Commerce for the coordination and planning of Federal civil programs in marine observations and predictions. Because of the interactions between programs dedicated to support civil interests and the marine environmental activities of the Department of Defense, close liaison is maintained with that Department to ensure that elements of Defense activities are included, jointly coordinated, and planned with the civil MAREP program.

The principal tasks of coordinating MAREP activities and of preparing and maintaining the Federal Plan are performed by the Interagency Committee for Marine Environmental Prediction. This Committee was established on March 4, 1970.


The Interagency Committee for Marine Environmental Prediction and its subgroups conduct systematic, continuous reviews of basic and specialized requirements, services, and relevant research in MAREP. Currently, two long-range Federal Plans are being developed under the auspices of the Committee: (1) A Plan for Collection, Exchange, and Dissemination of Data in Real-time for Marine Environmental Prediction Services; and (2) A Plan for Improvement of Marine Environmental Prediction Techniques. Long-range specialized plans in other important areas of MAREP that need improvement and coordination are also contemplated.

This Plan covers programs for FY 71 and FY 72 of all participating Federal agencies.

The first section of the Plan identifies objectives and goals toward which planning and coordination of MAREP Services are directed, followed by descriptions of the Federal and international activities in marine environmental prediction and related programs, and a summary of fiscal data. Next, the Basic and Specialized MAREP Services are each presented from an operational point-of-view, along with the relevant research programs that will contribute immediately and in the long term to the improvement of individual Services.

A handwritten signature in black ink, reading "Robert M. White". The signature is written in a cursive, flowing style with a large initial "R".

Robert M. White
Federal Coordinator for
Marine Environmental Prediction



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CONTENTS

Preface	ii
Needs and Objectives	1
Federal Activities in Marine Environmental Prediction	3
International Activities	13
Summary of Fiscal Data	15
Marine Environmental Prediction Services	19
Basic Marine Environmental Prediction Service	20
Marine Environmental Prediction Service for Maritime	
Navigation	47
Marine Environmental Prediction Service for Water	
Pollution Control	50
Marine Environmental Prediction Service for Fisheries	
Interests	54
Marine Environmental Prediction Service for Mineral	
Exploration	59
Marine Environmental Prediction Service for Specialized	
Military Applications	60

Needs and Objectives

Marine Environmental Prediction (MAREP) Services have been initiated and efforts are being made to improve them for governmental and non-governmental needs and in recognition of the growing numbers of citizens concerned with the marine environment, both for pleasure and livelihood. The term "marine environment" is intended, insofar as this Plan is concerned, to embrace the deep ocean, the coastal zone, and the Great Lakes.

Many interests are focused on the oceans because of the economic potential of both living and non-living resources. Considerable recent concern has been generated, both nationally and internationally, regarding the deteriorating quality of our marine environment, and control mechanisms proposed have called for extensive monitoring capabilities.

Oceans, at times, can be a hostile environment for men and equipment that are engaged in activities on, in, or near them. The MAREP Services are developed to aid men in making optimum use of the environment through judicious planning of their activities in the interest of protecting lives and property from undue exposure to hazardous conditions. Records show that 249 U.S. flag vessels in the merchant and fishing vessel categories alone were lost in the past 5 years from foundering, capsizing, or sinking which were the result of flooding caused by encountering storms and other adverse environmental conditions.

A broad spectrum of national defense operations have registered requirements for accurate and timely MAREP Services. The MAREP objectives of the United States can also be furthered through participation by this Nation in international programs that include various aspects of MAREP.

The MAREP Services are also applicable to activities in public recreation, including bathing, surfing, and boating. During 1970, it was estimated that 40 million people took part in recreational boating activities involving 8.5 million registered

recreational boats in the United States. In particular, the coastal warning system, tide predictions, various radio warnings to boaters, and general products of marine meteorology are valuable to public recreation.

In view of the foregoing, the goals for Federal efforts in MAREP are:

- To develop an integrated environmental monitoring system that will satisfy effectively the needs for physical, chemical, and biological data from oceanic and contiguous regions to support service-oriented programs and to facilitate effective control of environmental pollution.
- To provide an integrated program for marine prediction and information services including timely warnings of hazardous environmental conditions—both natural and manmade—on the high seas, in coastal waters, and on the Great Lakes for the protection of life and property.
- To provide assessment and predictions of the distribution and abundance of the living marine resources of principal importance to the United States.

The Federal program for MAREP Services is envisaged as being supported by the interlocking systems with functions performing the following:

- ☐ Sensing or data acquisition;
- ☐ Data collection and relay by means of telecommunications;
- ☐ Data processing and product formulation, product and services dissemination; and
- ☐ Data archiving.

In each of these systems, expansion and improvements are planned in order to achieve the goals established. Relevant research and technology development are now in progress and are to be expanded for the purpose of improving existing Services and of meeting new demands for marine environmental prediction.



Hazardous Breaker Activity over the Columbia River Bar



Aftermath of a Tsunami—Kodiak, Alaska—1964

Federal Activities in Marine Environmental Prediction

The wide range of Federal prediction products and services and of relevant research and technology development projects reflects action being undertaken in response to a broad range of current and potential user requirements in marine environmental prediction (MAREP). The Departments of Commerce, Defense, Interior, and Transportation, the Atomic Energy Commission, the Environmental Protection Agency, the National Aeronautics and Space Administration, the National Science Foundation, and the Smithsonian Institution either conduct or fund efforts in or related to MAREP. The involvement of a large number of Federal agencies is indicative of the extensive influence of the marine environment upon many social and economic activities. Accordingly, MAREP efforts are integral elements of programs being conducted in fulfillment of the respective agency missions.

The specific programs or projects of each of the Government departments and agencies engaged in activities relating to MAREP are presented.

To reflect the association of Federal activities with comparable international activities, a brief description of the latter is included in a separate section which immediately follows the description of Federal activities.

DEPARTMENT OF COMMERCE

The Department of Commerce, through its National Oceanic and Atmospheric Administration (NOAA), is the principal civilian agency of the Federal Government involved in MAREP activities. NOAA was created on October 3, 1970, under Executive Reorganization Plan 4 which brought together in one agency the following elements:

- The Environmental Science Services Administration from the Department of Commerce.
- The Bureau of Commercial Fisheries, Marine Game Fish Research Program, and Marine Minerals Technology Center from the Department of the Interior.
- The National Data Buoy Development Pro-

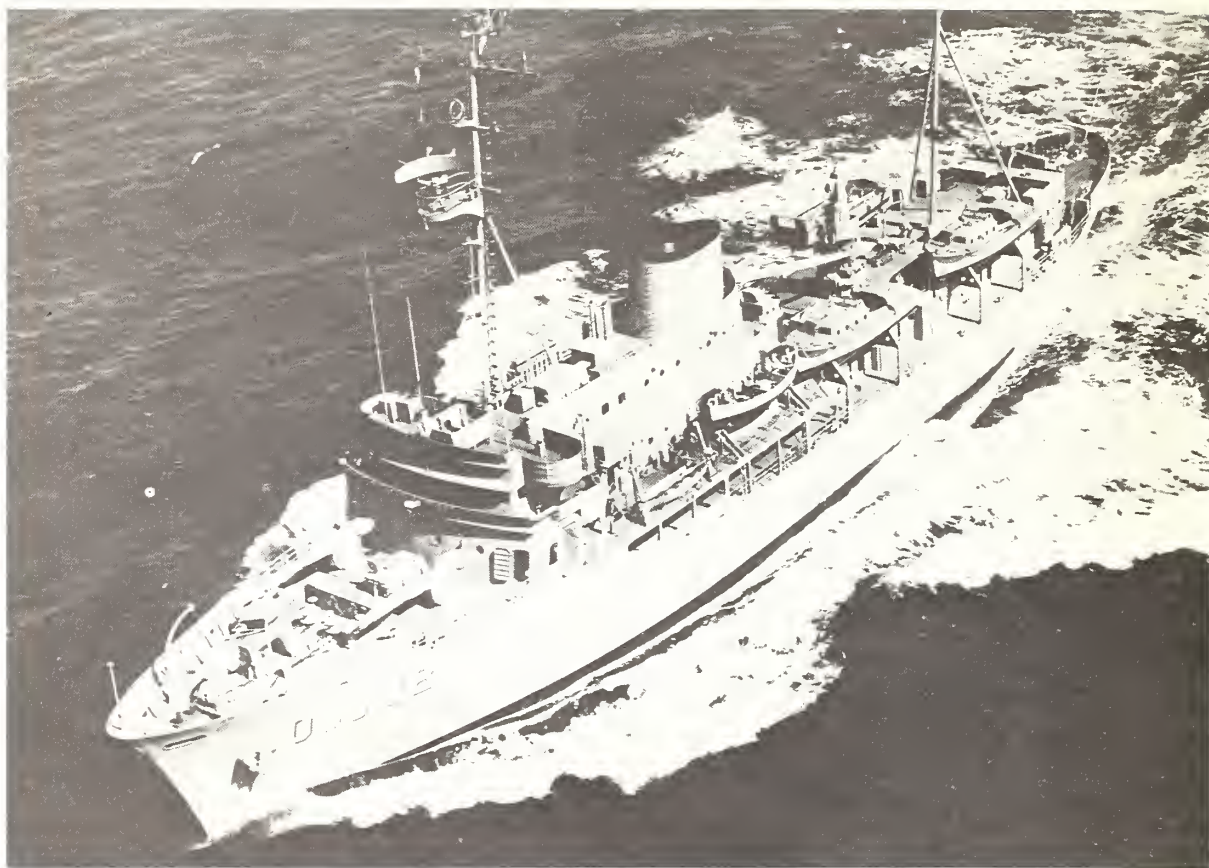
ject from the Department of Transportation.

- The National Sea Grant Program from the National Science Foundation.
- Elements of the U.S. Lake Survey from the Army Corps of Engineers.
- The National Oceanographic Data Center.
- The National Oceanographic Instrumentation Center.

NOAA was created to focus in a single agency most programs designed to improve man's comprehension and use of the physical environment and oceanic life. The mission of NOAA is to organize a unified approach to the understanding of problems of the ocean and the atmosphere, the provision of a wide-range environmental monitoring, prediction and information service to support the national effort to avert environmental deterioration, to provide the environmental information for public and specialized activities and for the protection of life and property, to improve the efficiency of marine operations, and to permit the proper management of marine resources. This service mission and the research relevant to it are conducted within the NOAA interim organization by the following:

- ☐ National Weather Service
- ☐ National Ocean Survey
- ☐ National Marine Fisheries Service
- ☐ Environmental Data Service
- ☐ National Environmental Satellite Service
- ☐ Environmental Research Laboratories
- ☐ National Data Buoy Project Office
- ☐ National Oceanographic Instrumentation Center
- ☐ Marine Minerals Technology Center

The National Weather Service (NWS) of NOAA is the principal Federal activity responsible for providing the Basic Meteorological Service to the Nation; it also furnishes Specialized Meteorological Services for particular user groups. Included among these Services are the issuances of forecasts, warnings, and other information concerning marine weather and related ocean conditions—such as



Ocean Survey Vessel DISCOVERER (National Ocean Survey)

waves and sea ice—for the benefit of commerce, navigation, fisheries, offshore drilling and mining, recreation, and other marine activities. The foregoing services are included as elements of the Marine Meteorological Service.

The National Ocean Survey (NOS) of NOAA makes and issues predictions on the times and heights of high and low waters caused by the astronomical tide and predictions of tidal currents. The Pacific Tsunami Warning System, established in 1948, is centered in Honolulu, Hawaii; a regional center exists in Palmer, Alaska. The System provides warnings to coastal regions and islands of possible danger from runup caused by seismic sea waves. Such warnings are disseminated to 15 countries and territories in the Pacific Ocean Basin. The Lake Survey Center of NOS engages in projects aimed at achieving a better understanding of the natural environment of the Great Lakes and at developing techniques for predicting manmade changes to it. The objective of these projects is to ensure optimum management and development of water- and land-related resources.

The National Marine Fisheries Service (NMFS) of NOAA is responsible for promoting conservation and efficient use of living marine resources for their esthetic, economic, and recreational value to the people of the United States. Efforts center on estimating and predicting the abundance, distribution, and condition of resource species and on determining the consequence to these resources from natural variations of the environment, pollution, harvesting, and other alterations of the environment resulting from human activities.

The National Environmental Satellite Service (NESS) of NOAA operates spacecraft which are equipped to observe and collect environmental data on a global basis; these data are broadcast to 50 countries through 500 readout stations. Regular products of NESS include charts of ice and snow cover for the Northern and Southern Hemispheres and cloud cover and other meteorological data used by the NWS and by components of other agencies and nongovernmental users. Operational production of sea-surface temperature charts will begin in 1971. The NESS also issues bulletins giv-

ing the position and intensity of tropical oceanic storms as interpreted from satellite data.

The Environmental Data Service (EDS) of NOAA provides for the collection, processing, storage, and retrieval of environmental data. The National Oceanographic Data Center (NODC) of EDS, colocated with World Data Center A (Oceanography) of the International Council of Scientific Unions, manages most of the Nation's and a large portion of the world's archived oceanographic data. The National Climatic Center (NCC) of EDS archives data produced by the NWS, including those data on sea-surface temperature and waves; the NCC is also responsible for marine data coverage over one of nine areas of the world oceans in accordance with procedures of the World Meteorological Organization (WMO).

The Environmental Research Laboratories (ERL) of NOAA conduct programs in air-sea interaction research, geophysical fluid-dynamic modeling studies, ocean current systems investigations, internal wave studies, and associated equipment development.

The National Oceanographic Instrumentation Center (NOIC) of NOAA provides services to MAREP through the testing and evaluation of oceanographic instrumentation and through the coordination of specifications for such instrumentation.

The National Data Buoy Project Office (NDBPO) of NOAA is responsible for developing the national capability to deploy networks of unmanned telemetering environmental buoys, preparatory to the deployment of an operational system.

The Marine Minerals Technology Center (MMTC) of NOAA is responsible for a specialized research program to give assurances that the extraction of minerals from the ocean will not produce damaging effects on other marine resources and on the marine environment.

DEPARTMENT OF DEFENSE

Agencies of the Department of Defense maintain extensive MAREP Services to support the Department's responsibilities for national security and for the Civil Works Program of the Nation, including navigation improvements, flood control, shore protection, and regulatory activities for the preservation and protection of navigable waters. The principal managers of these MAREP Services are the Office of the Oceanographer of the Navy, the Naval Weather Service Command (NWSC), and the Army Corps of Engineers. Relevant research programs are conducted by the Corps of Engineers for the Army and by the Office of Naval Research



Ocean Modelling Research (Environmental Research Laboratories of NOAA)

(ONR), the Naval Oceanographic Office (NAVOCEANO), the NWSC, and the Systems Commands and Laboratories of the Navy Materiel Command for the Navy. In addition, the Navy provides oceanographic support to the NMFS of NOAA for fishing areas off the west coast and cooperates with the Coast Guard in connection with the International Ice Patrol in the North Atlantic Ocean.

The Naval Weather Service Command (NWSC) furnishes operational marine prediction support to the fleet for all categories of naval operations, including amphibious operations, antisubmarine warfare, search and rescue missions, polar missions, and transoceanic shipping. The Navy Fleet Weather Centrals and Facilities have operational oceanographic divisions which are manned by environmental scientists trained in both meteorology and oceanography. The Fleet Numerical Weather Central (FNWC), Monterey, Calif., is the hub of the vital computer network established to

process data for product formulation. Fleet Weather Centrals at Rota, Spain, Norfolk, Va., Alameda, Calif., Pearl Harbor, Hawaii, and Guam in the Mariana Islands, function as regional oceanographic analysis centers.

The Naval Oceanographic Office (NAVOCEANO) is responsible for developing oceanographic prediction techniques and for applying them on an experimental basis to naval operations. As these techniques are proven of value they are transferred to the NWSC for application in support of naval operations. Similarly, the Naval Weather Research Facility at Norfolk develops techniques for marine meteorology. Through funding from the National Aeronautics and Space Administration (NASA), the NAVOCEANO manages the Spacecraft Oceanography (SPOC) Project whose mission is to determine those oceanographic measurements which can be made from space and to assist in the development of appropriate sensors.

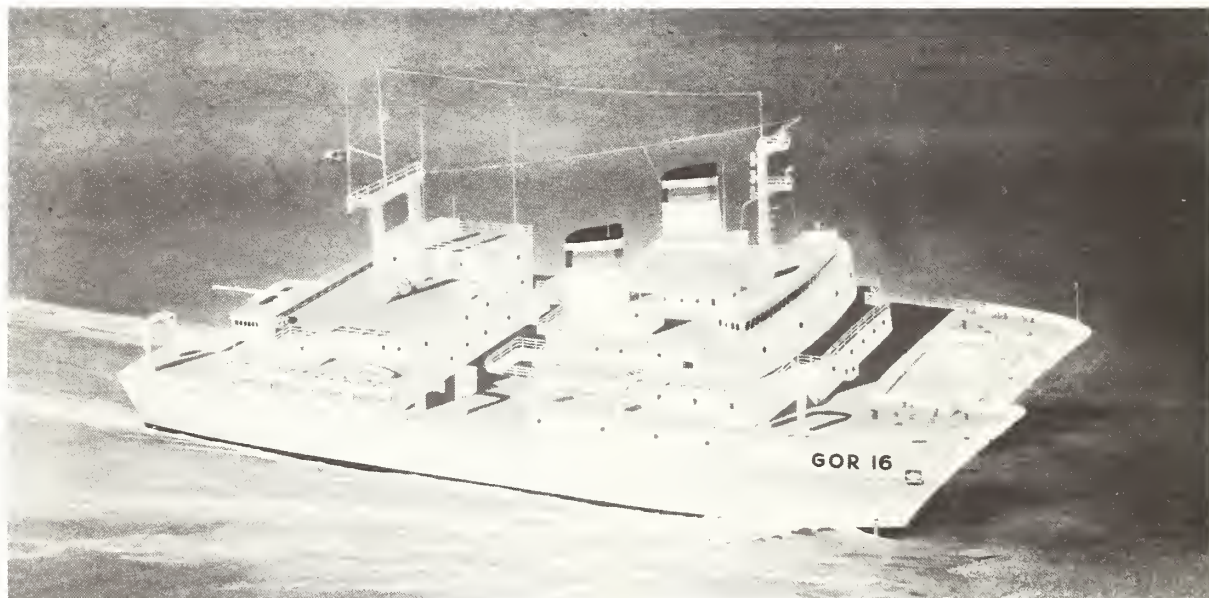
The Office of Naval Research (ONR) supports an extensive university research program in the marine sciences (the Defense equivalent of that at the National Science Foundation). Studies of fundamental environmental characteristics and environmental modeling are accomplished in accordance with directed requirements within the Navy and are the basis for the development of environmental prediction techniques. Studies cover a wide spectrum of areas such as air-sea interaction, internal motions (waves and currents), thermal structure, coastal dynamics, and ice dynamics.

The Army Corps of Engineers is concerned with nationwide planning, design, construction, and operation and maintenance of facilities for waterborne navigation, flood damage prevention, shore protection, and with certain regulatory activities for the preservation and protection of navigable waters. The Civil Works Program is applicable to the 50 States and also serves Puerto Rico and those possessions and territories under U.S. guardianship. All of these efforts include some short- and long-range prediction related to beach erosion, tsunami runup, hurricane flooding, other storm surges, dredging operations, pollution and flushing characteristics of bays and estuaries, regulation of reservoirs, emergency operations related to oceanic storms, and protection and preservation of navigable waterways, as well as the preservation of fish and wildlife and the protection of the environment through the regulatory activities of the Corps.

The field agencies of the Corps which accomplish the major effort in these activities are the Districts and Divisions, supported by the Army Coastal Engineering Research Center, the Waterways Experiment Station, the Cold Regions Research and Engineering Laboratory, and the Hydrologic Engineering Center.

DEPARTMENT OF THE INTERIOR

The U.S. Geological Survey (USGS) of the Department of the Interior conducts research and develops operational techniques for calculating the circulation of water and associated solids and so-



Oceanographic Research Ship HAYES (U.S. Navy)

lutes in estuary and lagoon waters from tide-stage and other data. It makes geologic and hydraulic studies of sediment movement into and in estuaries. In cooperation with States and other agencies, the USGS maintains programs of measuring the amount and rates of fresh-water inflow and water-quality parameters. It also carries on an expanding program of monitoring the background water quality within estuaries and similar coastal waters.

The Department of the Interior, through the Geological Survey, is responsible for supervising the operations of Federal oil and mineral lessees on the outer continental shelf. It exercises this responsibility to specify equipment and techniques for preventing and controlling the pollution of ocean waters which can result from mineral operations. In its surveillance of these operations, USGS inspectors record and report to the proper authority all pollution observed, regardless of its source.

The Department of the Interior formerly had a large effort in marine living resources through the Bureau of Commercial Fisheries (BCF) and the marine sports fishing program of the Bureau of Sport Fisheries and Wildlife (BSFW) and had responsibility for pollution control in waters of the coastal zone through the Federal Water Quality Administration (FWQA). As a result of Executive Reorganization Plans 3 and 4, these activities were transferred, respectively, to the Environmental Protection Agency (EPA) and to the National Oceanic and Atmospheric Administration (NOAA). The Geological Survey's responsibility for background and long-term monitoring of water quality, for basic water resources investigations and research, and for coordination and collection of water data, remains in the Department of the Interior.

DEPARTMENT OF TRANSPORTATION

In the Department of Transportation, the Coast Guard has statutory responsibility to provide MAREP Services through the conduct of the International Ice Patrol, the safeguarding of lives and property at sea, the fulfillment of its icebreaking missions, and the conduct of such oceanographic research as may be in the national interest. A wide variety of environmental data is collected, processed, and relayed for use by the Marine Meteorological Service and by other users. Prediction products are often distributed by Coast Guard facilities in the course of routine activities or by those Coast Guard units having primary responsibilities related to MAREP.

The Coast Guard promotes the safety of life and property on and over the high seas and in the wa-

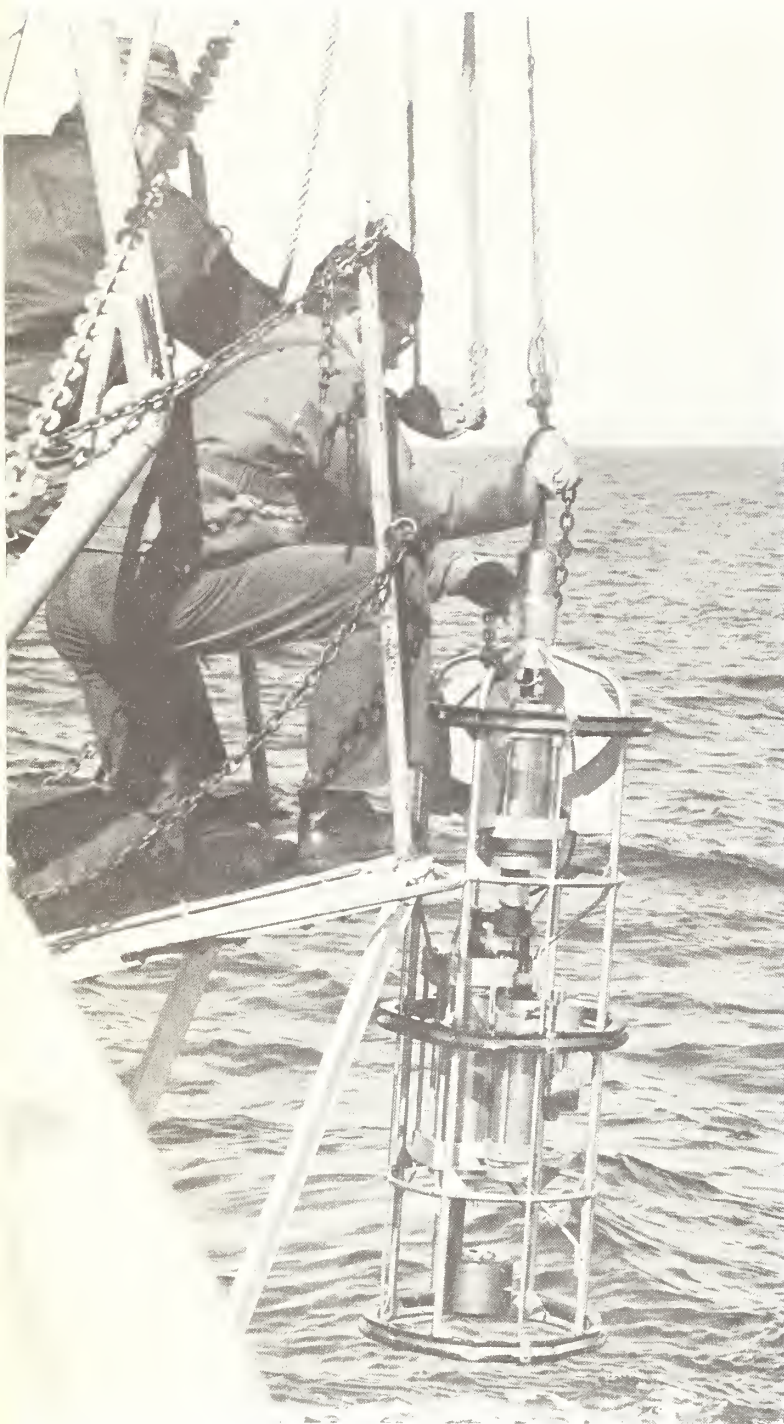


Sampling Water and Suspended Sediment in the Columbia River Estuary at Astoria, Oregon, for Radionuclide Concentrations (U.S. Geological Survey for the Atomic Energy Commission)

ters over which the United States has jurisdiction through dissemination of weather forecasts and warnings prepared by other Government agencies. The Coast Guard supports a broad range of Federal marine programs which include providing its own specialized forecast services for certain flight operations, for cases that involve aircraft ditchings, and for other search and rescue operations that require specialized sea-condition information.

Much of the marine data collection capability of the Coast Guard lies in its major vessels. Included among these are oceanographic ships as well as Ocean Station Vessels and polar icebreakers equipped with standard oceanographic equipment.

Coast Guard ships continuously man seven Ocean Weather Stations, providing complete upper air, surface, and subsurface environmental information to both NOAA and the Department of Defense. NOAA provides the meteorological personnel on board. Coast Guard radio stations or other communications facilities support the program of



Salinity-Temperature-Depth (STD) Device
(U.S. Coast Guard)

collection and dissemination of weather information by NOAA.

The Coast Guard also provides MAREP Services to a variety of marine environmental monitoring interests in the form of periodic oceanographic surveys and airborne measurements of sea-surface temperature. These Services, in cooperation with the NMFS of NOAA, are for the area of responsibility of the International Commission for Northwest Atlantic Fisheries (ICNAF). On-going coastal monitoring programs will be expanded in FY 72 into a network of environmental surveillance stations. Cooperative projects with a number of institutions under a National Science Foundation (NSF)/Office of Naval Research (ONR) contract are carried out from many Coast Guard vessels, offshore platforms, and shore facilities. Coast Guard resources are also cooperatively employed in projects of the Environmental Protection Agency, the Navy, and the Army Corps of Engineers.

ATOMIC ENERGY COMMISSION

The Atomic Energy Commission (AEC) has the overall responsibility for promoting, developing, and regulating the use of nuclear energy in such diverse fields as medicine, power production, military weapons, and peaceful nuclear explosives. The AEC has the added responsibility of protecting the health and safety of the public and, therefore, must be able to describe and predict the distribution and effects of radioelements and related factors in the marine environment.

The Commission supports oceanographic research directed toward determining those environmental factors which influence the movement of radioelements through the marine environment, possible radiation effects on marine biota and biotic processes, possible means and rate of return of radioactivity to man through the marine food chain, and basic ecological processes. This research also includes studies on marine biology, physical and chemical oceanography, use of radioisotopes to solve oceanographic problems, ultimate fate of radioisotopes in the ocean, and problems related to operational activities such as the effects of waste heat from nuclear power stations to determine the impact of heated water on the biota of the coastal zone. In addition, the AEC investigates the effects of water waves generated from nuclear detonations.

ENVIRONMENTAL PROTECTION AGENCY

As a result of Executive Reorganization Plan 3 of 1970, a new independent agency, the Environmental Protection Agency (EPA), was established within the Executive Branch on December 2, 1970.



In situ Measurement of Radioactivity in Marine Sediments (Oregon State University for the Atomic Energy Commission)

The EPA brings together in a single organization the following Federal pollution programs formerly existing in separate agencies and in an interagency council:

- The Federal Water Quality Administration (FWQA) from the Department of the Interior.
- The National Air Pollution Control Administration (NAPCA) from the Department of Health, Education, and Welfare (DHEW).
- Parts of the Environmental Control Administration (ECA)—Bureaus of Solid Waste Management, Water Hygiene, and a portion of the Bureau of Radiological Health—from DHEW.
- The pesticides research and standard-setting program of the Food and Drug Administration (FDA) from DHEW.
- The pesticides registration authority from the Department of Agriculture.
- The authority to perform general ecological research from the Council on Environmental Quality (CEQ).

- Certain pesticide research authority from the Department of the Interior.
- The environmental radiation protection standard-setting function from the AEC.
- The functions of the Federal Radiation Council (FRC).

The mission of the EPA is to organize the fight against environmental pollution on an integrated basis by acknowledging the critical relations among pollutants, forms of pollution, and control techniques.

Of particular importance to MAREP are the efforts by the Water Quality Office (formerly the FWQA) in pollution surveillance. This Office is concerned with planning and developing programs for the collection, evaluation, and dissemination of pollution control information, particularly as they relate to the implementation of water quality regulations. The Water Quality Office has developed, in cooperation with the USGS, information on water-quality baselines and trends. It plans and manages programs concerned with water-quality improvement. Research programs of the Water



The Floating Laboratory CLEAN WATERS
(Water Quality Office of the Environmental Protection Agency)

Quality Office, relating to environmental prediction in the estuaries and coastal zone, are included in the categories of water-quality control technology. These programs involve the study of the deposition of pollutants in coastal waters, the research into thermal pollution, and water-quality requirements for safe recreational uses and balanced marine life.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The National Aeronautics and Space Administration (NASA) investigates the possibilities of applying the tremendous potential of space technology for the benefit of man in his own environment. NASA contributes to the Nation's Basic Meteorological Service and, more specifically, to marine meteorology through its responsibility for launching and giving logistic support to the National Operational Meteorological Satellite System (NOMSS) and to other satellite systems and through its own research program. The mission of NASA's meteorological program is to develop and



Improved TIROS Operational Satellite (ITOS-1)
(National Aeronautics and Space Administration)

improve space technology in both satellite and sounding-rocket systems for use in exploring, understanding, and defining the structure of the atmosphere and for use in predicting its behavior, with particular emphasis on operational application.

NASA's activities in oceanography are primarily concerned with research and development efforts to explore the potential of applying space technology, remote sensing techniques, and related data-gathering systems to the acquisition of information on ocean-surface temperature gradients, water color, and sea-state conditions as well as oceanic phenomena such as upwelling and ocean currents. The majority of NASA's oceanographic activities are conducted within the framework of the Earth Resources Survey Program. NASA relies on the SPOC Project Office within the NAVOCEANO for technical and administrative assistance involving the letting of research contracts with scientific investigators, the monitoring of their work, and the coordinating of plans for NASA aircraft oceanographic missions.

NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is authorized and directed to initiate and support basic and applied scientific research and programs to strengthen the scientific research potential in the physical and other sciences. In the Division of Environmental Sciences of the Foundation, the Physical Oceanography Program supports investigations into ocean dynamics and mechanisms that determine the distribution of heat and materials within the sea. Interactions between ocean and atmosphere are studied under this Program and also under the Atmospheric Sciences Program. Research programs in atmospheric sciences that support MAREP involve those of the National Center for Atmospheric Research (NCAR), the Office of Polar Programs, Weather Modification Programs, and the Global Atmospheric Research Program (GARP). The NSF also supports research which will provide information for predictions of biological aspects of the marine environment, including organism distribution, growth rate, reproduction, and potential harvest.

The U.S. Program for participating in the International Decade of Ocean Exploration (IDOE) is

administered by the NSF through its Office for the IDOE. The Program presently gives emphasis to three major subjects: environmental quality, environmental forecasting, and seabed assessment. As lead agency, NSF coordinates planning and funding of the U.S. Program for the IDOE and allocates funds to agencies, universities, and private organizations involved in IDOE projects.

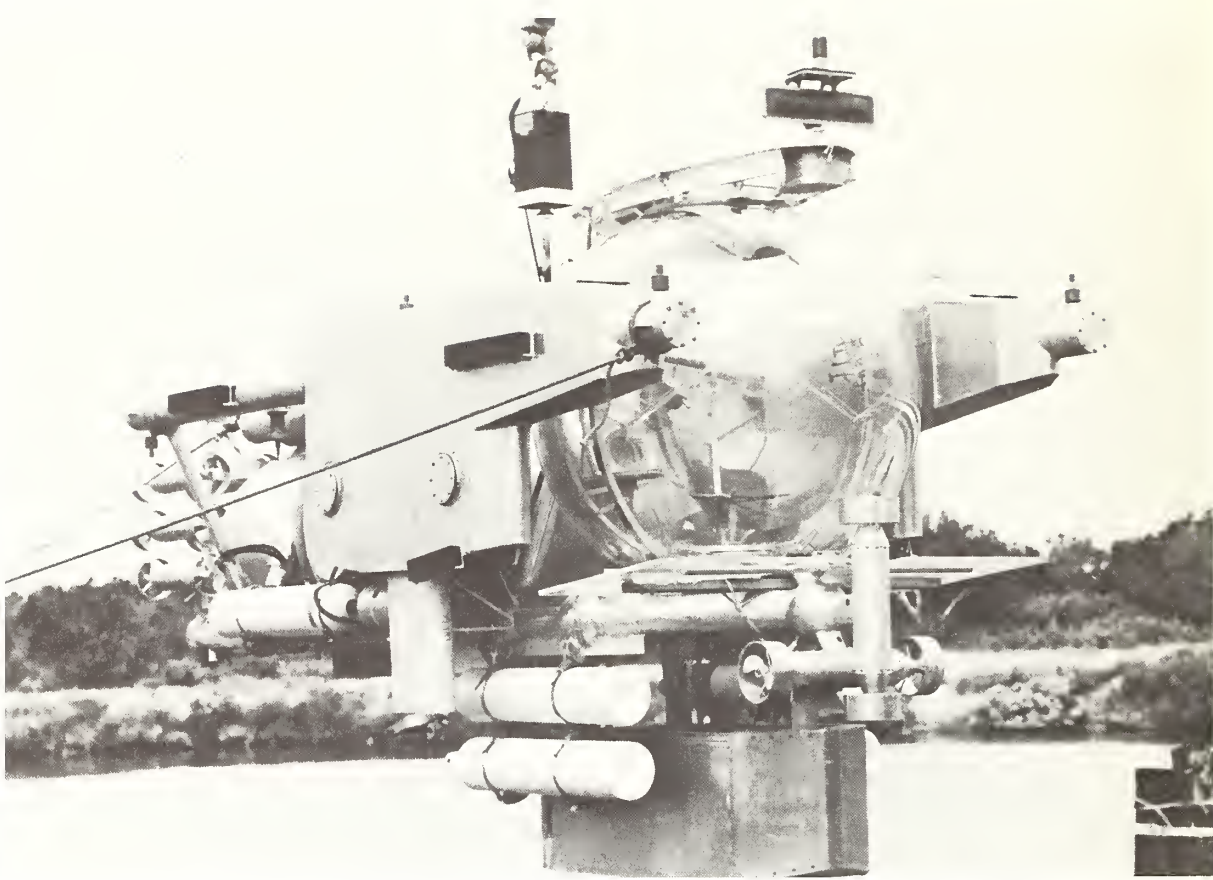
SMITHSONIAN INSTITUTION

The Smithsonian Institution, one of the world's largest research centers and museum complexes, is devoted to public education, basic research, and national service in the arts, sciences, and history. It has a large program of basic research on the primary identification and description of the forms of life in the sea and of their geographical distribution. The vast collection of specimens are a major basic source of information concerning the life in the sea.

The Smithsonian Oceanographic Sorting Center (SOSC) is a service unit of the Smithsonian's Museum of Natural History. The SOSC assists in the national and international oceanographic effort by processing biological and geological specimens for



The USNS ELTANIN, Operated for the Office of Polar Programs of the National Science Foundation



The JOHNSON-SEA-LINK, New Research Submersible of the Smithsonian Institution, Capable of Dives to 1,000 Feet

scientists throughout the world; through its activities, marine collections are made available to scientists everywhere. Marine collections have come from many national and international expeditions including, among others, the International Indian Ocean Expedition, the U.S. Antarctic Research Program cruises, the International Cooperative Investigations of the Tropical Atlantic, and the Guinean Trawling Survey. The Mediterranean Marine Sorting Center (MMSC) in Tunisia, also operated by the Smithsonian, serves as the biological center for Cooperative Investigations of the Mediterranean, coordinated by the Intergovernmental Ocean-

ographic Commission of UNESCO.

The Smithsonian Institution conducts research programs which contribute to the understanding and prediction of marine phenomena that occur over long time scales. These programs include estuarine and tropical marine ecological studies at the Chesapeake Bay Center for Environmental Sciences and at the Smithsonian Tropical Research Institute, respectively.

The Institution also cooperates with the Navy in the Ocean Acre project, an extensive and comprehensive study of the acoustic and biological characteristics of a single water column.

International Activities

The United Nation's (UN) General Assembly has maintained continuing interest in marine science activities. The UN and its specialized agencies have continued to expand their activities in marine science on a worldwide basis, with the substantial support and the participation of the United States. Of particular significance is the Integrated Global Ocean Station System (IGOSS), a program of the Intergovernmental Oceanographic Commission (IOC) which is viewed in many ways as the international counterpart of MAREP Services of the United States.

The IGOSS is intended to be an amalgamation of national environmental monitoring and prediction systems brought together as a dynamic worldwide system for measuring or observing the marine environment, communicating or collecting and processing the data, and providing or disseminating a variety of products in real-time for use by marine interests. The IGOSS is a service-oriented program concentrating on the marine environment; it is being planned and developed in close conjunction with the World Weather Watch of the World Meteorological Organization (WMO). The World Weather Watch is an international cooperative program designed to make available to each participating Nation the basic meteorological information that the Nation requires, thus providing its users with the most efficient and effective meteorological service possible.

The IGOSS program was established through the adoption of IOC Resolution V-20 in September 1967 to give consideration to the growing need for oceanic data on a global scale by a wide range of users, including those in forecasting services, research, engineering, navigation, commerce, and fisheries. An International Committee, made up of Member States most active in the field, was established to plan and coordinate the development of the IGOSS program, both within the IOC and jointly with WMO and other interested international organizations. The "General Plan and Im-

plementation Program of IGOSS for Phase I," developed through close collaboration between the IOC and WMO, was adopted by the IOC's 6th Session Resolution VI-7 in September 1969. The Plan was subsequently approved for implementation by the WMO in December 1969.

A pilot project for the collection, exchange, and evaluation of selected oceanographic data on an international basis is being planned by the IOC and WMO for late 1971. Such a project will mark a significant milestone in the realm of international cooperation under the aegis of the United Nations system. It will be the initial exchange of bathythermal observations by high-speed telecommunications that have been set up under the agreements within the UN system. The Global Telecommunications System (GTS) of the WMO World Weather Watch will be used as the principal means for data exchange.

Oceanographic research related to the on-going development of the IGOSS is being identified in conjunction with the IOC's Long-Term and Expanded Program of Oceanic Exploration and Research (LEPOR). The LEPOR is being implemented in accordance with the UN General Assembly Resolution 2560 (XXIV) of December 13, 1969. Serving as a stimulus and acceleration phase for LEPOR, the International Decade of Ocean Exploration (IDOE) also includes oceanographic research of benefit to the development of IGOSS. The IDOE was proposed by the United States in March 1968 and adopted by the UN General Assembly as an international commitment on December 21, 1968, through its Resolution 2467D (XXIII). Intergovernmental planning for both the IDOE and LEPOR by participating nations was begun in June 1969; in the United States, planning for the IDOE began in 1968.

Consideration is also being given to the possibility of conducting oceanographic experiments of potential benefit to the development of IGOSS in conjunction with the Tropical Experiment of the

Global Atmospheric Research Program (GARP), sponsored jointly by the International Council of Scientific Unions (ICSU) and the WMO. Problems of ocean-atmosphere interaction have also been identified as part of the LEPOR; work on these problem areas is recognized as being interrelated with the GARP.

Monitoring of marine pollutants and the effects of pollutants on the marine environment are subjects of considerable interest to the international community. A joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) was established in 1969 to provide advice on the scientific and technical aspects of marine pollution problems and to develop proposals for cooperative programs of action with respect to pollution monitoring and control. The GESAMP is sponsored jointly by the Inter-Governmental Maritime Consultative Organization (IMCO), the Food and Agriculture Organization (FAO), the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the World Meteorological Organization (WMO), the World Health Organization (WHO), and the International Atomic Energy Agency (IAEA)—all specialized agencies of the UN or closely allied to the organization. In December 1970, the FAO convened a Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing which adopted several resolutions toward improved international cooperation in relation to monitoring techniques and urged that increased efforts be given to pollution re-

search. The Conference also urged that the recommendations be brought to the attention of the United Nations in connection with the 1972 Conference on Man and His Environment.

Several international cooperative investigations of the ocean are expected to make scientific contributions toward further development of MAREP. Among such investigations in the planning stage or in progress are: the Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR), the organization and implementation of which are coordinated by the IOC; and the Cooperative Investigation of the Northern part of the Eastern Central Atlantic (CINECA), the organization and implementation of which are being coordinated by the International Council for Exploration of the Sea (ICES) with the FAO, WMO, and IOC.

On the basis of a bilateral agreement, there was established in 1964 a United States-Japanese Cooperative Program in Natural Resources Development (UJNR). With the UJNR program on marine science, there was formed in 1970 a U.S. Panel on marine environmental observations and forecasting. Following the initial meeting of the U.S. Panel with its counterpart in Japan, recommendations were made as follows: (1) to continue close coordination of the two panels; (2) to encourage the exchange of scientists; (3) to promote the exchange of data, technical reports, and other related information; and (4) to coordinate plans for the monitoring of large-scale features of the dynamics of the Pacific Ocean.

Summary of Fiscal Data

The following tables summarize fiscal information for programs of the Federal Government associated with marine environmental prediction (MAREP). The funds shown are those used to provide services and to support relevant research that has both long- and short-term objectives to improve services. Information on observations made from land and marine stations for the unique purpose of collecting data for the Basic Meteorological Service is not included in this Plan, but is reported in the annual *Federal Plan for Meteorological Services and Supporting Research*. The Marine Meteorological Service, discussed as a Specialized Meteorological Service in the aforementioned Plan, is included as an integral part of this Plan for MAREP; appropriate sections contain funding information for and descriptions of the Marine Meteorological Service as it relates to MAREP.

The fiscal information for operations in MAREP and for relevant research is presented by agency and by service in the first two tables, "Federal Plan

for Marine Environmental Prediction, by Agency" and "Federal Plan for Marine Environmental Prediction, by Service"; data for FY 71 programs and for planned activities for FY 72 are included as proposed in the President's budget. The total Federal expenditure in MAREP planned for FY 72 is \$145,197,000, with an increase of \$19,806,000 over FY 71. Most agencies plan activities at level funding or with modest increases, while total MAREP costs for the Department of Defense in FY 72 show a decrease. The largest increases are those of the Departments of Commerce and Transportation.

In the operations area, total MAREP costs for FY 72 are expected to be \$60,540,000, a net increase of \$5,965,000 over FY 71. The largest single part of the Department of Commerce planned increase of \$5,370,000 results from the assumption of full support of the National Oceanographic Data Center. The remainder of this Commerce increment is accounted for by implementation of the initial phases of acquisition and processing of data in

FEDERAL PLAN FOR MARINE ENVIRONMENTAL PREDICTION, BY AGENCY (in thousands of dollars)

	Operations			Relevant research			Total		
	FY 71	FY 72	Net difference	FY 71	FY 72	Net difference	FY 71	FY 72	Net difference
Commerce	9,980	15,350	+5,370	25,167	33,817	+8,650	35,147	49,167	+14,020
Defense	29,645	27,733	-1,912	11,706	12,824	+1,118	41,351	40,557	- 794
Interior	1,050	1,193	+ 143	1,466	1,574	+ 108	2,516	2,767	+ 251
Transportation	13,300	15,464	+2,164	7,881	10,484	+2,603	21,181	25,948	+ 4,767
AEC				6,813	7,085	+ 272	6,813	7,085	+ 272
EPA	200	200 ¹		3,100	3,100 ¹		3,300	3,300 ¹	
NASA				1,563	1,563		1,563	1,563	
NSF				13,020	14,010	+ 990	13,020	14,010	+ 990
Smithsonian	400	600	+ 200	100	200	+ 100	500	800	+ 300
Total	54,575	60,540	+5,965	70,816	84,657	+13,841	125,391	145,197	+19,806

¹ FY 72 projections for EPA are level-funded pending further deliberations by that Agency, which has been established only since December 1970.

FEDERAL PLAN FOR MARINE ENVIRONMENTAL PREDICTION, BY SERVICE
(in thousands of dollars)

	Operations			Relevant research			Total		
	FY 71	FY 72	Net difference	FY 71	FY 72	Net difference	FY 71	FY 72	Net difference
Basic	27,418	29,433	+2,015	39,782	48,710	+8,928	67,200	78,143	+10,943
Maritime navigation	3,932	3,619	-313	481	992	+511	4,413	4,611	+198
Water pollution control	1,167	4,005	+2,838	13,686	16,653	+2,967	14,853	20,658	+5,805
Fishing interests	4,638	5,584	+946	7,246	8,546	+1,300	11,884	14,130	+2,246
Mineral exploration				97	297	+200	97	297	+200
Specialized military applications ..	17,420	17,899	+479	9,524	9,459	-65	26,944	27,358	+414
Total	54,575	60,540	+5,965	70,816	84,657	+13,841	125,391	145,197	+19,806

INTERAGENCY FUND TRANSFERS FOR MARINE ENVIRONMENTAL PREDICTION, BY AGENCY, FY 71
(in thousands of dollars)

Funds transferred from	Funds transferred to											
	Commerce		Defense re-search	Interior		Transportation		NSF re-search	Smithsonian re-search	Total		
	Operations	Re-search		Operations	Re-search	Operations	Re-search			Operations	Re-search	Both
Defense	1,648	106		37		50	46	20	35 ¹	1,735	207	1,942
Interior	23									23		23
Transportation	416									416		416
AEC		303	10		145						458	458
EPA	22			70						92		92
NASA		230	1,300		33						1,563	1,563
NSF		2,552 ³							89 ¹		2,641	2,641
Total	2,109 ²	3,191 ²	1,310	107	178	50	46	20	124	2,266	4,869	7,135

¹ Smithsonian is a quasi-governmental agency and funds reported as transfers are acquired through contracts with the private sector of the Institution.

² Includes funds originally transferred to Defense for the National Oceanographic Data Center, subsequently acquired by Commerce per Reorganization Plan 4.

³ Includes funds transferred from NSF to NOAA under the IDOE.

the Marine Resource Monitoring and Assessment Program (MARMAP) and by expansions of marine weather and sea forecast services and of satellite operations for acquisition and processing of oceanic data.

The operations costs of the Department of Transportation show a net increase of \$2,164,000. The planned expansion of the Coast Guard's Coastal Zone Pollution Baselines and Monitoring Project amounts to \$2,764,000; however, this increase is offset by decreases which reflect completion of projects in FY 71 and transfer of ship support costs from service to research activities.

A Department of Defense decrease of \$1,912,000 for MAREP operations in FY 72 results principally from closing of several weather/oceanographic offices, decrease of support for postgraduate training in oceanography, and the transfer of funding responsibilities for NODC to Commerce.

The planned expenditures for FY 72 research and development programs relevant to MAREP Services total \$84,657,000, showing an increase of \$13,841,000 over FY 71. The \$8,650,000 Department of Commerce increase is due to new or expanded efforts in connection with the International Field Year of the Great Lakes (IFYGL), the Trop-

ical Atlantic Experiment of the Global Atmospheric Research Program, and a variety of projects on environmental quality, physical oceanography, MARMAP, and improvement of marine predictions by the National Weather Service. Department of Transportation increases, totaling \$2,603,000, result from expanded research efforts in combating hazardous materials pollution and in improving sea-ice reconnaissance, as well as the shift in certain ship support costs to research projects.

The major programs of the Federal agencies which contribute to the several MAREP Services listed in the table, "Federal Plan for Marine Environmental Prediction, by Service," are discussed, together with planned improvements, in succeeding sections of the Plan.

The "Interagency Fund Transfers for Marine Environmental Prediction, by Agency, FY 71,"

shows the extent to which Federal agencies are making use of each other's capabilities in arranging for MAREP Services or relevant research by inter-agency transfers in FY 71.

The MAREP products and services are generated through the operation of a system made up of four interlocking functions plus a support function. As treated in this Plan, these five functions are: data acquisition, communications, data processing, information dissemination, and general agency support. These functions are further explained in the next section under the description of the Basic MAREP Services; however, a summary of fiscal information arranged according to the functions is also given in the tables: "Agency Operational Costs, by Function," "Agency Manpower Engaged in MAREP Operations, by Function," and "Agency Relevant Research Costs, by Function."

AGENCY OPERATIONAL COSTS, BY FUNCTION (in thousands of dollars)

	Data acquisition		Communi- cations		Data processing		Information dissemination		General agency support		Total	
	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72
Commerce	6,187	8,587	88	113	1,491	4,096	1,684	1,974	530	580	9,980	15,350
Defense	10,580	7,847	2,058	2,063	6,276	6,890	2,743	2,854	7,988	8,079	29,645	27,733
Interior	842 ¹	978 ¹			23				185	215	1,050	1,193
Transportation	11,102	13,510	357	178	1,114	1,076	223	196	504	504	13,300	15,464
EPA	142	142 ²					58	58 ²			200	200 ²
Smithsonian	100	200			270	360	30	40			400	600
Total	28,953	31,264	2,503	2,354	9,174	12,422	4,738	5,122	9,207	9,378	54,575	60,540

¹ The funds listed are about 50 percent of total data acquisition costs of the U.S. Geological Survey, the remainder being provided by States and local agencies through cooperative agreements. These costs include data processing, not identified by the Survey as a separate function.

² FY 72 projections for EPA are level-funded pending further deliberations by that Agency, which has been established only since December 1970.

AGENCY MANPOWER ENGAGED IN MARINE ENVIRONMENTAL PREDICTION OPERATIONS, BY FUNCTION (in man-years)

	Data acquisition		Communi- cations		Data processing		Information dissemination		General agency support		Total	
	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72
Commerce	377	409			183	198	50	61	20	22	630	690
Defense	474	458	195	178	473	455	233	204	756	680	2,131	1,975
Interior	85	100							8	8	93	108
Transportation	1,203	1,225.5	10	12	61	55	6	6	53.5	53.5	1,333.5	1,352
EPA	7	7					2	2			9	9
Smithsonian	2	3			7	9	1	2			10	14
Total	2,148	2,202.5	205	190	724	717	292	275	837.5	763.5	4,206.5	4,148

AGENCY RELEVANT RESEARCH COSTS, BY FUNCTION
(in thousands of dollars)

	Research directed toward improvement of												Total	
	Data acquisition		Communications		Data processing		Information dissemination		Basic understanding of environment		Agency support of research			
	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72
Commerce	14,453	15,003			603	923	1,066	1,276	9,045	16,615			25,167	33,817
Defense	5,538	5,743	60	70	1,845	1,870	2,376	2,381			1,887	2,760	11,706	12,824
Interior	50	50							1,223	1,320	193	204	1,466	1,574
Transportation ...	7,837	10,484					44						7,881	10,484
AEC									6,813	7,085			6,813	7,085
EPA									3,100	3,100 ¹			3,100	3,100 ¹
NASA	1,563	1,563											1,563	1,563
NSF									13,020	14,010			13,020	14,010
Smithsonian									100	200			100	200
Total	29,441	32,843	60	70	2,448	2,793	3,486	3,657	33,301	42,330	2,080	2,964	70,816	84,657

¹ FY 72 projections for EPA are level-funded pending further deliberations by that Agency, which has been established only since December 1970.

Marine Environmental Prediction Services

As indicated earlier, the general public, national defense, and specialized elements of the economy collectively require marine environmental information to perform effectively and safely their daily activities and to plan for future activities. Many of these needs can be fulfilled by a basic service while others require specialized applications.

The Basic Marine Environmental Prediction (MAREP) Service of the United States is intended to meet the needs of the general public, to fulfill those requirements which are common to two or more user groups, and to provide the foundation for the Specialized Services.

Specialized MAREP Services provide the facilities, products, and distribution mechanism necessary to serve specific user groups. Such Specialized MAREP Services include those for maritime navigation, water pollution control, fisheries interests, mineral exploration, and specialized military applications.

The MAREP Services and plans for their improvement, through expansion of operations and through relevant research directed toward service improvements, are discussed in the succeeding sections.

Basic Marine Environmental Prediction Service

DESCRIPTION OF SERVICE

The Basic Marine Environmental Prediction (MAREP) Service provides fundamental observations and forecasts used by interested members of the general public, governmental agencies, specialized user groups, and many segments of the economy. This Basic Service also provides many of the observations, analyses and forecasts, and communications common to the Specialized Services in MAREP. It is recognized that certain meteorological observations, analysis and forecast centers, and their communication links which are provided primarily for the Basic Meteorological Service furnish invaluable support to the Basic and Specialized MAREP Services.¹

The principal observation networks, analysis and forecast centers, communications networks, and other facilities of the several Federal agencies which contribute wholly or in part to the specific support of the Basic MAREP Service are listed below:

- Oceanographic and related meteorological observations of Defense, using naval vessels, research ships, ships of opportunity, and reconnaissance and patrol aircraft.

- Oceanographic and meteorological observations by the Coast Guard using aircraft, fixed platforms, and vessels engaged in the Ocean Station Vessel Program, Standard Monitoring Sections, and other operations.
- Meteorological and related oceanographic observations of the Cooperative Merchant Ship Observational Program of NOAA.
- Satellite program of the Department of Commerce and NASA for the remote sensing of the marine environment, with later extension to the collection and transmission of data from *in situ* platforms.
- Tropical region reconnaissance by the cooperative efforts of the National Weather Service (NWS) of NOAA, the Department of Defense, and the Federal Aviation Administration (FAA).

BASIC MARINE ENVIRONMENTAL PREDICTION SERVICE, BY AGENCY

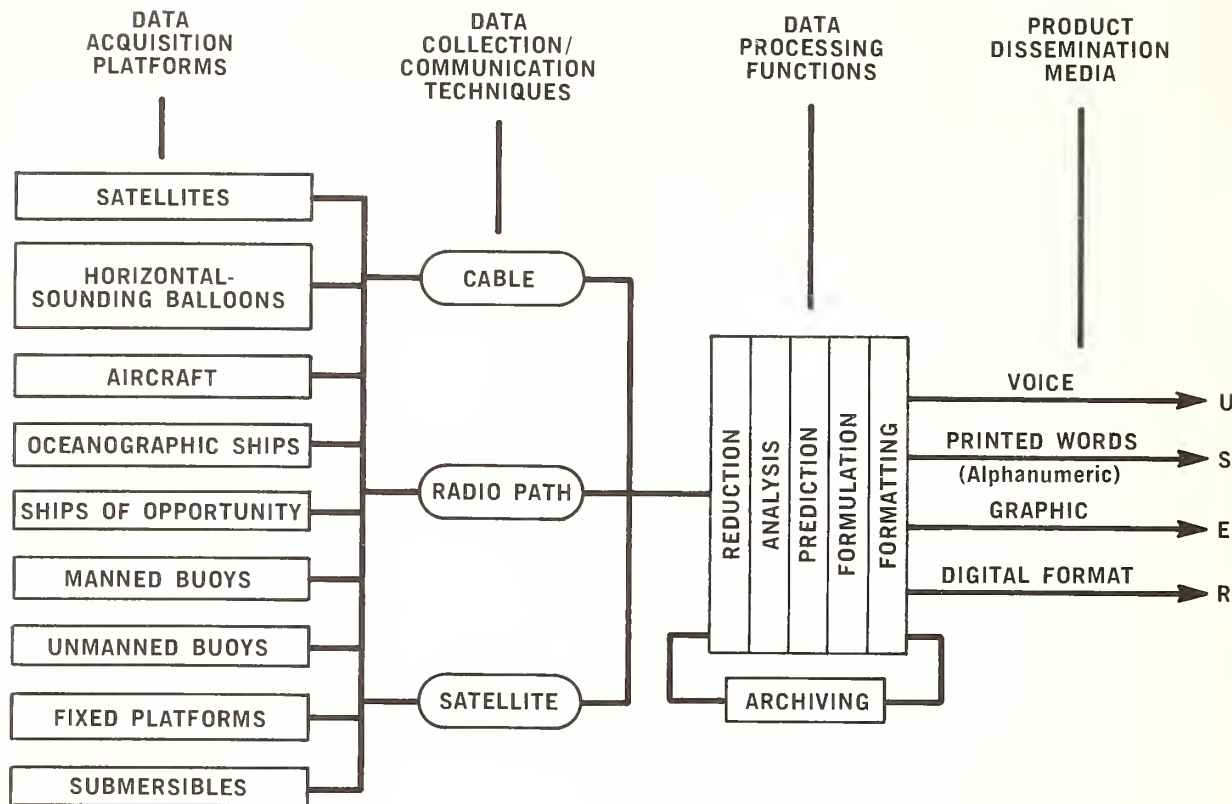
(in thousands of dollars)

	Operations		Relevant research		Total	
	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72
Commerce ..	5,428	9,708	18,159	24,649	23,587	34,357
Defense	9,163	7,013	1,530	2,282	10,693	9,295
Interior	1,050	1,193	1,466	1,574	2,516	2,767
Transportation	11,377	10,919	3,830	4,422	15,207	15,341
AEC			734	630	734	630
NASA			943	943	943	943
NSF			13,020	14,010	13,020	14,010
Smithsonian .	400	600	100	200	500	800
Total	27,418	29,433	39,782	48,710	67,200	78,143

¹ A full description of the Basic and other Specialized Meteorological Services is contained in the *Federal Plan for Meteorological Services and Supporting Research*, published annually by the Federal Coordinator for Meteorological Services and Supporting Research. Description of these Basic and Specialized Meteorological Services and the associated facilities will appear only incidentally in this Plan as they interface with MAREP Services, except in the case of the Marine Meteorological Service and tropical cyclone warnings which overlap but are integral parts of MAREP Services.

- Scheduled Defense and Coast Guard flights over the Atlantic and Pacific Oceans to collect sea-surface temperature and bathythermographic data from which mean monthly sea-surface temperature charts and Gulf Stream charts are produced for distribution.
 - Special procedures activated by the National East Coast Winter Storms Operational Plan which depend upon the cooperative reconnaissance and surface observation, analysis, and warning capabilities of the NWS, the Department of Defense, the FAA, and the Coast Guard.
 - Tide and tidal current prediction services and the Pacific Tsunami Warning System of the National Ocean Survey (NOS) of NOAA.
 - Marine data collection and relay by high-speed circuits and teletypewriter systems operated by the Departments of Commerce, Defense, and Transportation.
 - Processing, analysis, and forecast centers for marine services of the NWS, Department of Defense, and the Coast Guard.
 - Tropical analyses and storm and hurricane warnings by the NWS and the Department of Defense.
 - Dissemination of marine forecasts and warnings by means of continuous very high frequency/frequency modulation (VHF/FM) radio broadcasts of NOAA and those of commercial facilities.
 - Dissemination of marine forecasts and warnings by means of Defense and Coast Guard radio facilities.
 - The Coastal Warning System, a cooperative network of visual displays (flag and light) at locations on the seacoast, Great Lakes, and inland waterways.
 - Storage and retrieval of marine data and publication of marine atlases by the National Oceanographic Data Center (NODC) and the National Climatic Center (NCC) of NOAA, the Department of Defense, and the Smithsonian Oceanographic Sorting Center (SOSC).
 - Monitoring of streamflow and water quality in estuaries and the coastal zone and in the Great Lakes by the U.S. Geological Survey (USGS), the Department of Defense, and the NOS of NOAA.
 - Hydraulic, hydrologic, and sedimentation studies of the Army Corps of Engineers and the USGS and flood management services of the Department of Defense.
 - Establishment of techniques and secondary reference standards for the assessment of oceanographic instrument performance and for the collection and dissemination of information on performance and on instrument development programs by the National Oceanographic Instrumentation Center (NOIC) of NOAA.
- Marine environmental prediction (MAREP)—defined as the analyzing and forecasting of the physical, chemical, biological, and hydrodynamic states of the ocean, the overlying atmosphere, and their interactions—is treated as a total system made up of four interlocking functions plus a support function (see diagram). As indicated earlier, there are two categories of MAREP Services, Basic and Specialized. In general, the functions involved in the production of these Services are as follows:
- ☐ Data acquisition—the measurement of environmental parameters, made by various sensors that are mounted on fixed or moving platforms and that are deployed in the marine environment either as airborne, floating, or submerged.
 - ☐ Communications—the lifeline of the total system, employed for the collection, relay, and exchange of data for processing, archiving, and research support where appropriate; many of the facilities engaged in this function are also employed in the delivery of products resulting from the data processing function.
 - ☐ Data processing—product formulation in various forms, as required by users, such as analyses, forecasts, warnings of hazardous conditions, data summaries, and documentation for special study requirements.
 - ☐ Information dissemination—the delivery of products and services, involving output from data processing to the ultimate users so that these users can make operational decisions or conclusions on the basis of the information provided.
 - ☐ General agency support—activities which agencies must perform, such as training of personnel, maintenance of equipment and facilities, internal support, and management above the operating level so that the total system can be operated to provide MAREP Services effectively and efficiently.

MAREP SYSTEMS CONCEPT



MAREP Systems Concept

Some MAREP Services do not include real-time forecasts; consequently, all of the functional steps are not always applicable. In this section of the Plan, a general summary of Federal programs in the Basic MAREP Service is presented for the aforementioned functions.

DATA ACQUISITION

Observations for the Basic MAREP Service are obtained through a number of agency programs, using a variety of observing platforms and sensors. The diversity of requirements for the Basic Service and the variety of sampling methods result in mixed and multi-purpose data collection platforms and sensors. These factors, coupled with the need for standardization and the increase in definition of optimum space and time sampling intervals, are necessary considerations which are recognized in planning a complex yet responsive observational network for the Service.

Existing data acquisition techniques partially satisfy requirements for marine information from the

bottom and littoral zones, the subsurface zone, and the atmosphere and air-sea interaction zone. Measurement of the parameters in the last-named zone are made by aircraft, satellites, and horizontal balloons, and by radiosonde methods from ships and island stations as part of the Basic Meteorological Service. The Basic Meteorological Service and the observing programs of the Department of Defense contribute the observations from the atmosphere and air-sea interaction zone that are essential for MAREP, but which are reported in detail in the annual *Federal Plan for Meteorological Services and Supporting Research* and in the *Federal Plan for Marine Meteorological Services*. These observations are:

- ☐ Surface observations from land and oceanic areas to support broad-scale analyses and forecasts.
- ☐ Surface observations from the Cooperative Merchant-Ship Observational Program to supplement data coverage over the oceans.
- ☐ Surface observations from the Cooperative

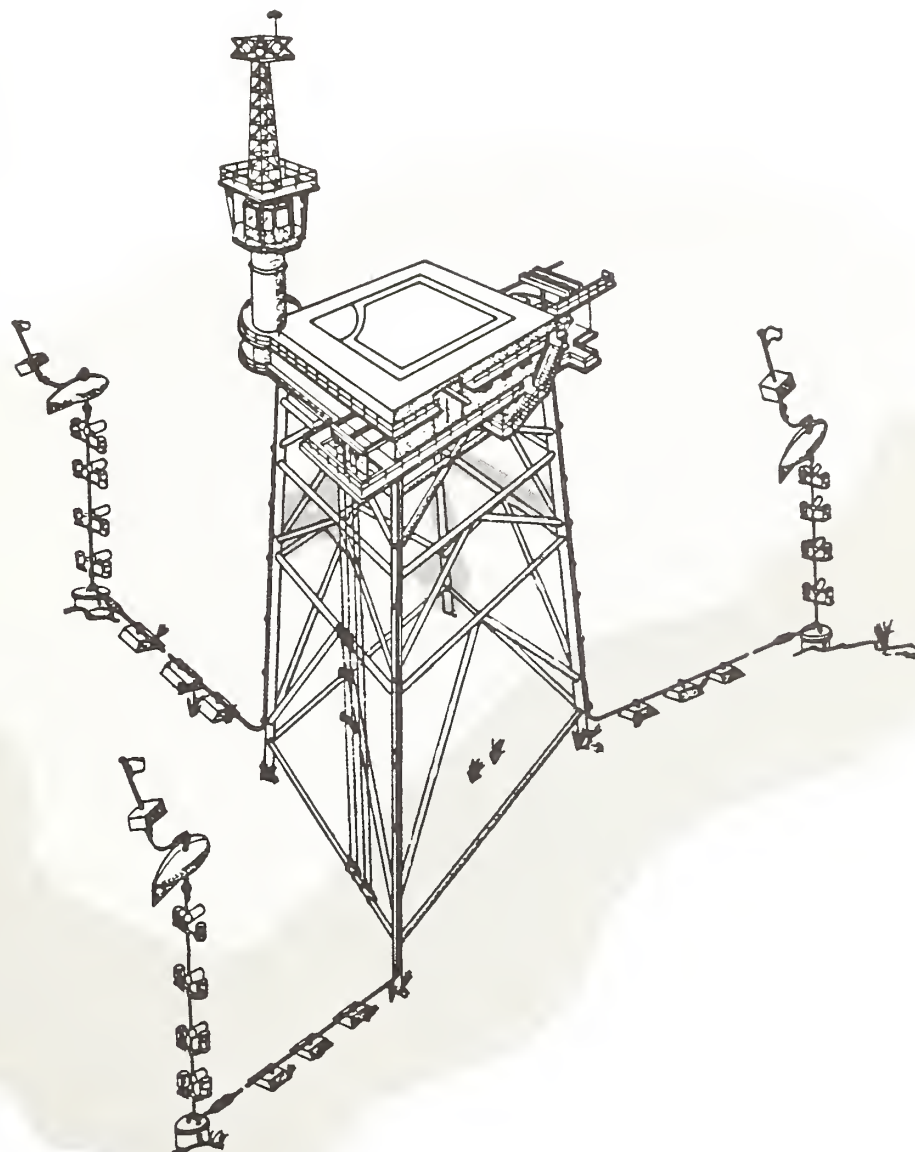
Coastal Observing Network to support detailed analyses for coastal and offshore areas.

- ☐ Upper air observations from land and ocean stations as fundamental inputs to atmospheric analysis and prediction.
- ☐ Weather radar observations of thunderstorms and precipitation over the coastal regions of the United States and observations of tropical cyclones and dangerous storms in the offshore areas.
- ☐ Weather satellite observations of the earth's cloud patterns on a daily basis as an aid to locate and estimate the intensity of storms

and tropical cyclones, especially in the less frequently traveled portions of the oceans.

- ☐ Aircraft reconnaissance measurements of the detailed characteristics and location of tropical cyclones and major storms over the oceans to support accurate, timely warnings to marine users.

Also reported in detail in the *Federal Plan for Meteorological Services and Supporting Research* is the information on marine stations tabulated below, from which surface meteorological data are obtained.



Proposed Shallow Water Ocean Sensor Array
(U.S. Coast Guard)

MARINE SURFACE METEROLOGICAL OBSERVATIONS

AGENCY	NUMBER OF LOCATIONS	
	FY 71	FY 72
Department of Commerce (Moving Vessels With Meteorological Personnel)	15	15
Department of Commerce (Cooperative Merchant-Ship Observational Program)	1650	1650
Department of Transportation (Coast Guard)	89*	89*
Department of Defense (Ships with Meteorological Personnel)	39	38
Department of Defense (Reporting Ships Without Meteorological Personnel)	550	550
Departments of Commerce and Transportation (Ocean Stations)	7	7

*In addition, 164 shore stations support marine meteorological activities.

Satellite observations of large-scale synoptic weather patterns over oceanic areas add substantially to the forecaster's information on atmospheric conditions, and thus enhance the predictions of oceanic storms. Pictures of sea-ice coverage are also useful in preparing information on the character and distribution of sea-ice fields.

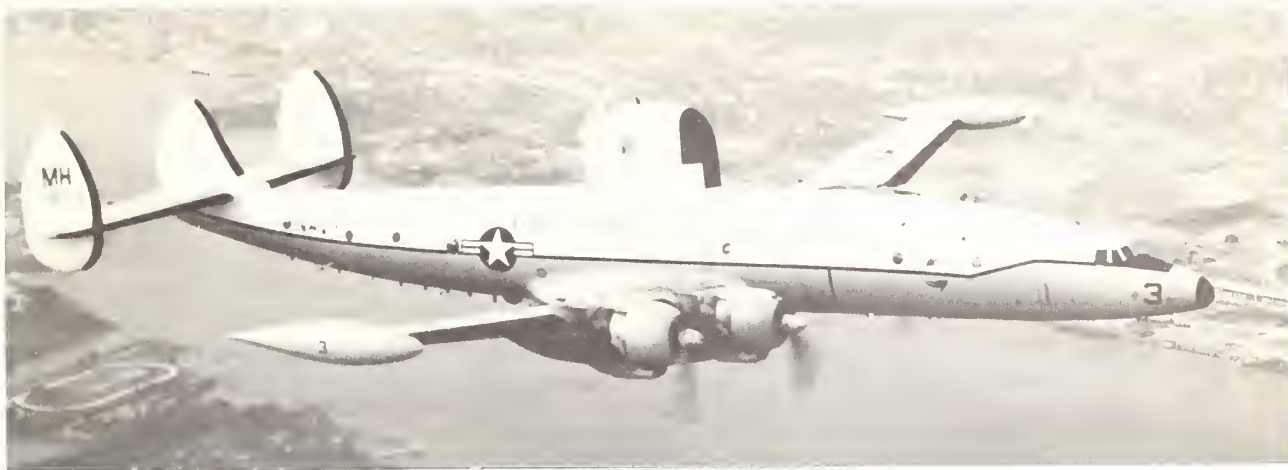
Military users also depend upon the Basic Meteorological Service for observational support, but their worldwide scope and frequently more demanding needs require more observational data beyond that provided by the Basic Meteorological Service programs. To meet this need for supplemental data, the Navy operates a marine observational program in which commissioned naval vessels record and report surface meteorological data

when underway and, under certain conditions, while in port. Surface observations are made at 6-hour intervals as an additional duty by nonmeteorological personnel aboard these ships. Antisubmarine warfare ships also report bathythermograph (BT) observations at 6-hour intervals. To fulfill requirements for more accurate and detailed observations and to perform other essential functions, meteorological personnel have been assigned and more sophisticated meteorological equipment have been provided to 39 ships. All of these ships make scheduled surface observations for synoptic and aviation purposes; 35 of them are equipped to make upper air observations. Defense also obtains data from Navy Oceanographic/Meteorological Automatic Devices (NOMAD). These NOMADs are unmanned buoys, currently undergoing research and exploratory development, and are instrumented to observe and transmit environmental data from oceanic areas. Although the Defense marine observational program is conducted primarily to fulfill military requirements, observational data are made available to other agencies.

The Department of Defense conducts an airborne measurement program to collect synoptic sea-surface temperature data by flying monthly tracks over the north wall of the Gulf Stream with an airborne radiation thermometer; this operational program cost is \$300,000 in FY 71. In another program with a cost of \$4,116,000 in FY 71, oceanographic information—consisting of sea-surface temperatures, dropsonde sampling, and oceanic reconnaissance—was acquired from weather reconnaissance aircraft.



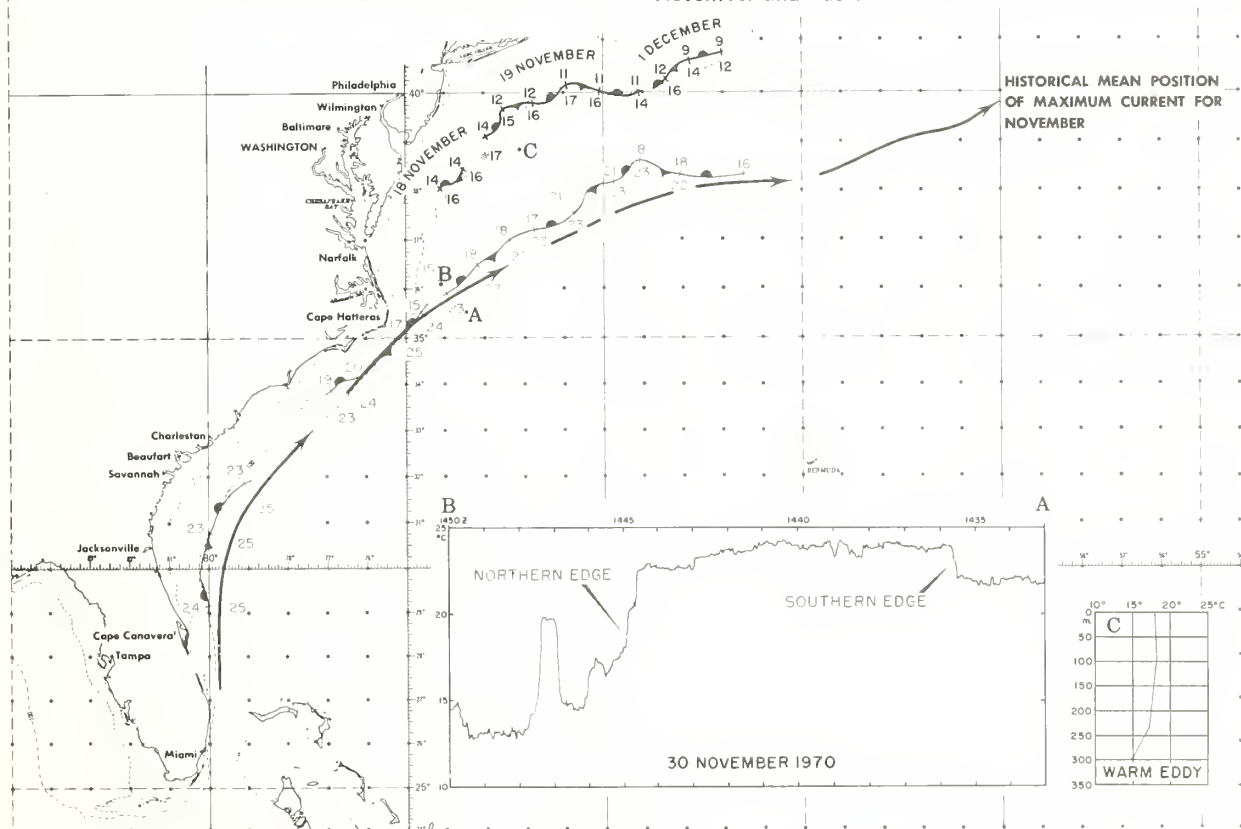
Ocean Station Vessel BOUTWELL



WC-121 Reconnaissance Aircraft (U.S. Navy)

On November 30 and December 1, NAVOCEANO aircraft surveyed the area north of 35°N . between the Gulf Stream and the Continental Shelf. Small meanders, warm-water overrunning (especially between 67°W . and 71°W .), and temperature changes of 2° to 8°C characterized the northern edge. The northern and southern edges of the Stream are shown in the airborne radiation thermometer trace.

A warm eddy containing Gulf Stream water was observed by several BT's airdropped near the Slope Front north of the Stream. A BT near the center of this eddy is shown. The Slope Front was tracked between 69°W . and 74°W . by a U.S. Coast Guard plane on November 18 and 19. This front was observed in almost the same position at the end of November and was tracked to 67°W . on December 1.



Gulf Stream Position—November 1970 (Naval Oceanographic Office)

Defense also maintains automatic weather stations at a cost of \$100,000 in FY 71 to provide oceanographic and meteorological data from sparse data areas.

The Department of Commerce, through the National Weather Service (NWS) of NOAA, acquires data in the atmosphere and air-sea interaction zone which are used more specifically for MAREP. Appropriations for these observations amounted to \$1,765,000 in FY 71 and included radar observations over the ocean from coastal sites, radio relay of ship reports, and management of the Cooperative Merchant-Ship Observational Program. Trained personnel and appropriate equipment are placed aboard Ocean Station Vessels to provide upper air, surface, and subsurface observations in sparse data areas. In association with the organization of NOAA, Executive Order No. 11564 was issued by which certain programs and activities were transferred to the Secretary of Commerce; among the transferred Defense programs was the Ocean Station Vessel program of meteorological support.

The Coast Guard conducts a number of programs in which oceanographic data are acquired in the air-sea interaction zone. Sea-surface temperature measurements are obtained on a monthly basis off both the Atlantic and Pacific coasts by use of airborne radiation thermometers. A portion of the Coast Guard program in polar oceanography contributes marine data for the air-sea interaction zone. In this regard, personnel on icebreakers are making routine oceanographic measurements while other observers are being provided access to polar regions for their observations.

The Department of Defense operates a relatively large subsurface synoptic oceanographic net, mostly in the Northern Hemisphere; yet, quantities of high-quality synoptic oceanographic observations are insufficient from many areas of the oceans. Larger quantities of daily temperature-depth profile observations are required to describe and predict properly the subsurface thermal features. Selected ships, both commercial and military, are equipped to make the necessary observations; some aircraft have the potential for providing the needed types of observations.

Improvements are being made in instrumentation to collect high-quality oceanographic data. In recent years, the Navy has introduced new and more precise devices—such as Near-Surface Reference Temperatures (NSRT) devices and airborne and surface expendable bathythermograph (AXBT and SXBT) equipment—to provide higher quality data. As more naval and civil vessels are equipped and then participate in the oceanographic pro-

grams, data coverage can be improved. Approximately 20 civil, fishery, and research ships were equipped with mechanical bathythermographs (BT) in the Ships of Opportunity Program of the Navy as of January 1, 1971; 70 civil ships were equipped with expendable Bathythermographs (XBT), with 10 more being outfitted during calendar year 1971. In FY 71, the Navy's subsurface data acquisition costs totaled \$4,208,000.

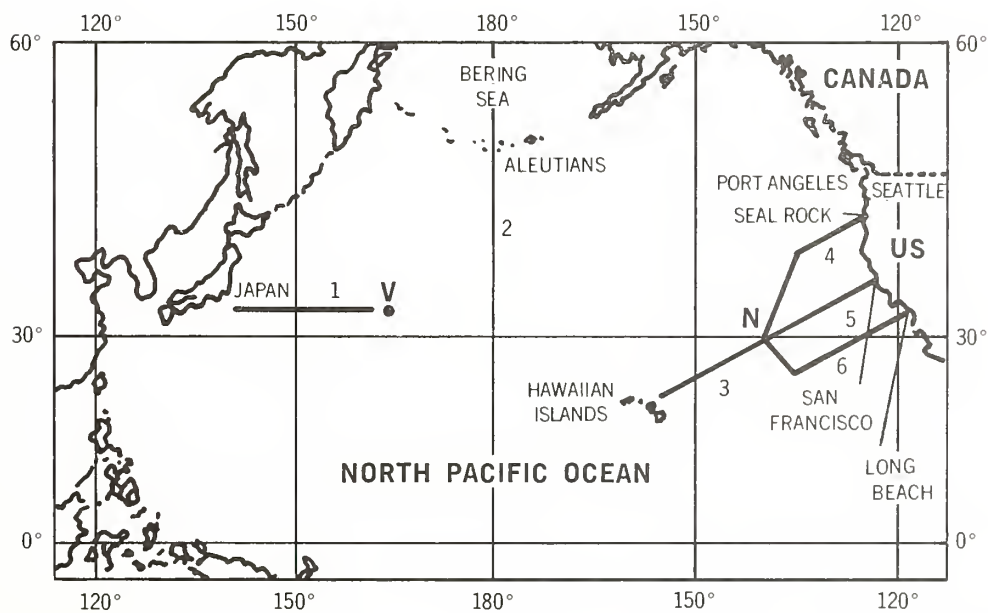
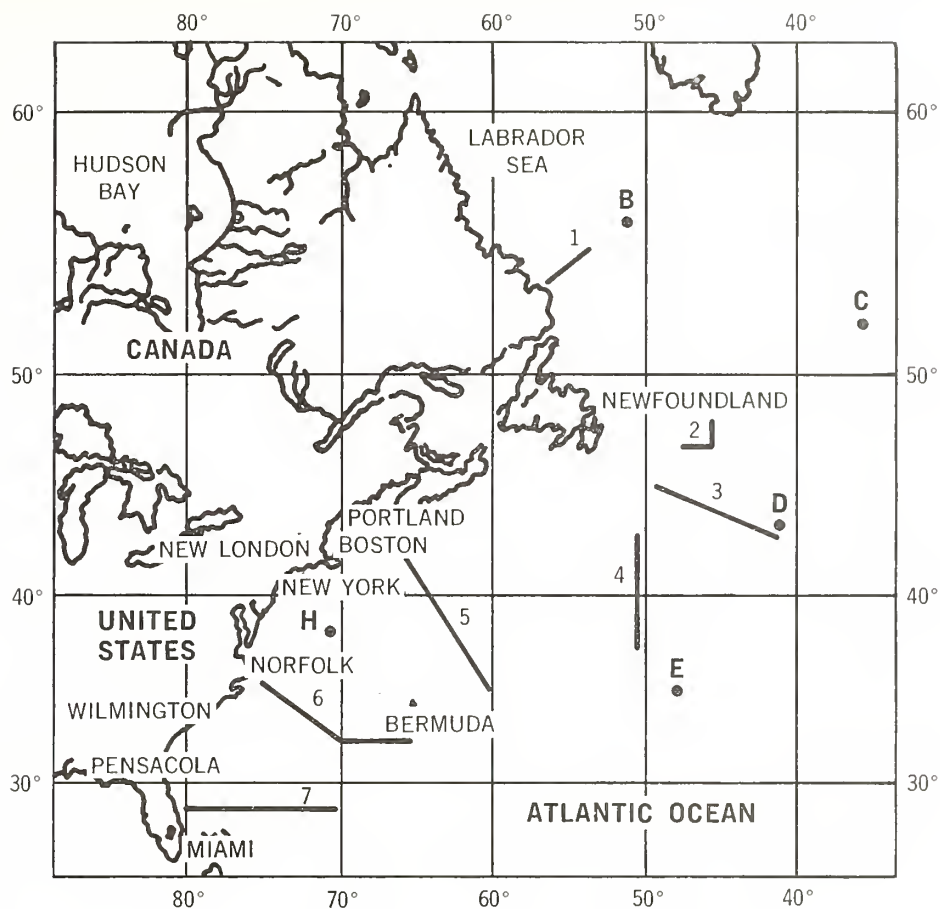
The total subsurface data acquisition program of the Coast Guard that contributes to MAREP cost \$11,536,000 in FY 71. A portion of that program, costing \$2,730,000 in FY 71, is conducted in connection with operation of the Ocean Weather Stations and the Standard Monitoring Sections. The accompanying figure illustrates this Coast Guard activity. The five Atlantic and two Pacific Ocean Weather Stations operated by the United States in accordance with international agreements provide continuous time-series oceanographic data from Nansen and salinity-temperature-depth (STD) casts. Standard sections are taken en route to and from the Ocean Weather Station so that vertical profiles can be constructed across regions of major interest. Subsurface data are also acquired in polar regions by Coast Guard icebreakers.

The National Ocean Survey (NOS) of NOAA operates a continuous control network of 120 tide gauges along the coasts and within the major embayments of the United States, Puerto Rico, territories and possessions, and the Trust Territory of the Pacific Islands. This tide gauge network is shown in an accompanying figure; 53 stations are also used to predict tidal currents and slack water. In addition, 150 temporary secondary stations were occupied during hydrographic surveys in FY 71 to increase the effective coverage of the control network. Operation of the tide station network cost \$162,000 in FY 71.

Forty-four of the Pacific area tide stations and 22 seismograph stations provided the input data in FY 71 for the Pacific Tsunami Warning System. The regional center at Palmer, Alaska, employs a network of four of these seismograph stations and seven tide stations.

At a total cost of \$300,000 in FY 71, operations of the NOAA ship FERREL contributed to marine data acquisition. Currents were measured at stations along coastal areas and in estuaries to provide information for predictions; current stations were tended in support of estuarine studies.

In FY 71, a total of \$44,000 was spent by the Army Corps of Engineers for data acquisition in support of a variety of engineering studies in the coastal zone. These include observations required



Ocean Station Vessel (OSV) Locations and Tracks for Standard Monitoring Sections



Control Tide Stations (National Ocean Survey)

for stream gauging, sedimentation studies, and information on the hydroclimatic network. Stream-flow and rainfall gauges, in addition to those operated by the U.S. Geological Survey (USGS) and the National Weather Service, were installed and operated in 1971.

Data acquisition activities of the USGS of the Department of the Interior in marine hydrology and hydraulics are limited to the coastal zone. Here the USGS measures the fresh-water inflow at coastal gauging stations, makes observations of dissolved mineral and organic constituents, obtains similar background data on water quality in estuaries and canals and natural channels adjacent thereto, operates tide-gauge stations for special purposes, and monitors the extent and magnitude of salt-water encroachment at certain localities. Under the Office of Management and Budget (OMB) Circular A-67, the USGS has responsibility for coordinating all water data activities in estuaries. Research activities of USGS in the coastal zone are described later in this section under the title "Relevant Research Program."

As of July 1, 1969, the USGS data collection network comprised over 600 stations at which fresh water inflow to estuaries is or could be computed. The accompanying chart shows the extent of this network. Most of the stations have a record of ade-



Permanent Tide Gauge Station (National Ocean Survey)



Beach Survey Party—Ludlow Island, N.J.
(Army Corps of Engineers)



Major Estuaries in Conterminous United States
Where Streamflow is Gauged (U.S. Geological Survey)

quate length (20 to 25 years), but it is estimated that about 50 additional stations would be needed to define total inflow to the sea to a degree sufficient for today's needs. Of some 400 new water quality monitoring stations presently planned in cooperation with the Water Quality Office of EPA, about 55 will be at or near the heads of estuaries around the conterminous States; a number will be placed around the Great Lakes and about 25 stations will be situated in coastal areas of Puerto Rico. In recent years, efforts have been made to increase substantially the amount of point-data collection in coastal waters and to initiate studies into the hydrology and hydrodynamics of typical estuaries. This data collection network also supports, in part, the Specialized MAREP Service for Water Pollution Control and is identified later in this Plan under the description of that Service.

The Smithsonian Institution employs marine scientists who are engaged in making collections of marine organisms throughout the world. In FY 71, \$100,000 was spent for collection of samples used for biological predictions.

COMMUNICATIONS

Just as observational data are required for broad-scale analyses and forecasts, the total system also depends for support upon the basic communication systems of the Basic Meteorological Service. The media used are listed below:

- ☐ Teletypewriter networks (Services C and O) operated by the FAA.
- ☐ Radar Reporting and Warning Coordination System (RAWARC)—a teletypewriter system operated by NOAA.
- ☐ Teletypewriter and high-speed circuits with overseas terminals for collecting and exchanging information.
- ☐ NOAA's Weather Wire Services—a teletypewriter network to distribute forecasts and warnings to the press, radio, and television.
- ☐ Facsimile networks operated by the Department of Commerce.
- ☐ Continuous VHF/FM radio broadcasts operated by NOAA. (These broadcasts on 162.55 or 162.40 MHz have a range of about 40 miles; 30 facilities at coastal or inland water locations are now in operation.)
- ☐ Teletypewriter and high-speed circuits operated by the Department of Defense.

Although these communications media supply a large measure of the communications support, they must also be supplemented by specialized civil and military facilities. There is an increasing reliance upon available high-speed civil and military com-

puter-to-computer data relay-and-exchange facilities. This includes Defense's automated environmental data networks. Commerce telecommunications links, such as those between Washington and Montreal, Canada; Washington and Offenbach, West Germany; Washington and Tokyo, Japan; and Washington and Melbourne, Australia, contribute principally to the Basic Meteorological Service.

Automatic marine telephone-answering services operate throughout the year at 40 coastal locations. These are employed to provide the latest forecasts and warnings for marine users in their areas. Similar information may be obtained on request from other coastal offices of the National Weather Service (NWS) of NOAA through listed telephones.

More than 2,000 commercial radio and television stations broadcast marine weather information several times daily without charge to the Federal Government as a public service of considerable benefit to small-boat operators. Forecasts and warnings for coastal and offshore areas are also transmitted through 31 Coast Guard and 50 commercial marine radiotelephone and radiotelegraph facilities. These stations, though generally low-powered, serve a broad spectrum of the maritime community. High-seas forecasts and warnings are broadcast for merchant ships operating in the western North Atlantic and eastern and central North Pacific Oceans by Defense, Coast Guard, and commercial radiotelegraph and radiotelephone broadcasts. Analyses and forecasts are also made available through Navy facsimile transmissions to suitably equipped merchant ships.

The Department of Transportation (Coast Guard) cooperates with the Department of Commerce (NWS of NOAA) by broadcasting coastal marine weather information to shipping and other maritime users. Broadcasts emanating from 31 locations fill gaps in commercial radio station coverage and, although carried out on a not-to-interfere basis, constitute a major effort by the facilities concerned. Broadcasts—usually plain language voice transmissions—are scheduled at 6- or 12-hour intervals, with warnings of hazardous conditions transmitted upon receipt and repeated periodically. The texts for these broadcasts are prepared by the NWS and delivered to the nearest Coast Guard communications office.

The Naval Communications System provides support for military users. Meteorological traffic is handled in the same manner as general traffic; there are no centers or units dedicated exclusively to serve as meteorological communications facilities. Additionally, the Naval Environmental Data

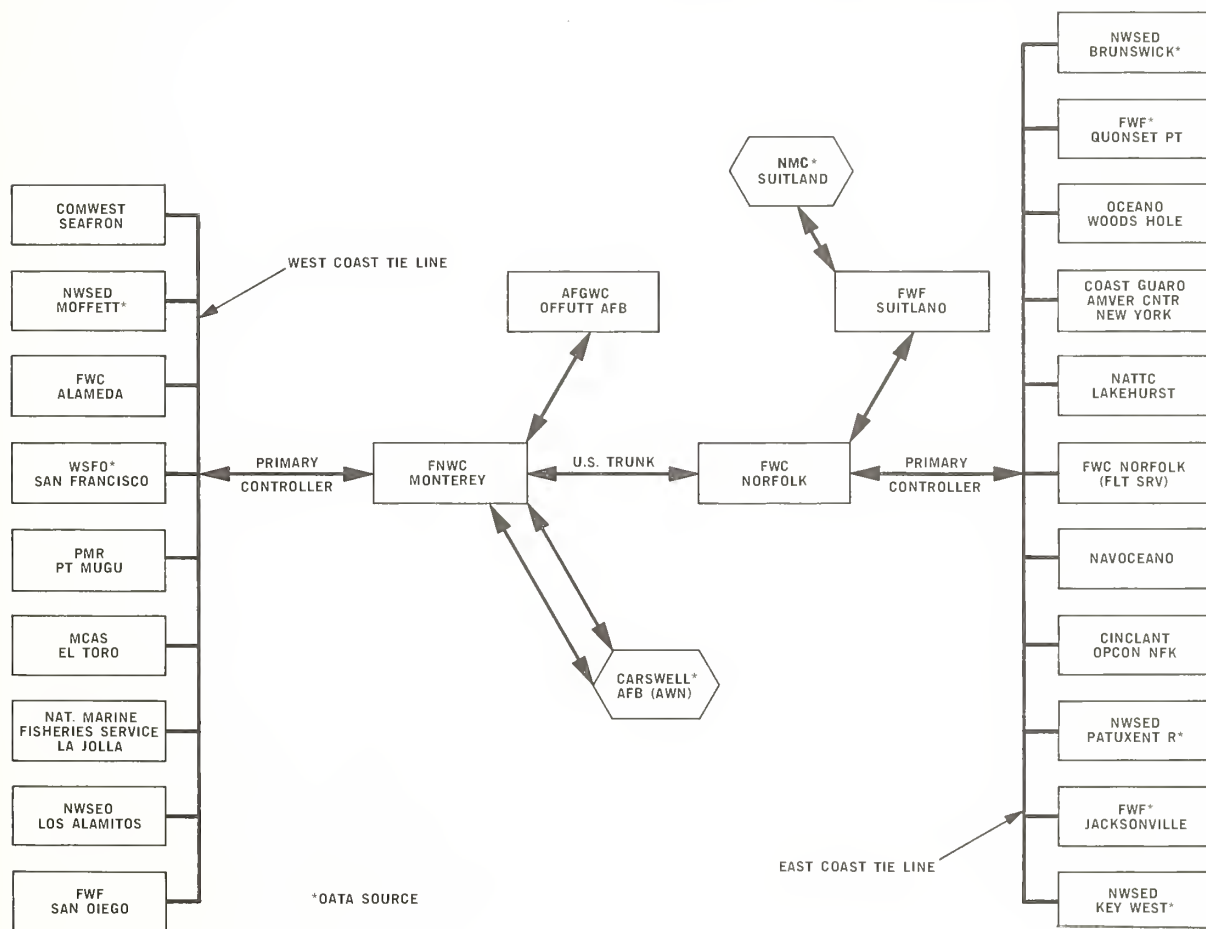
Network (NEDN) provides for the dissemination of meteorological and oceanographic computer-generated products from the Fleet Numerical Weather Central (FNWC) at Monterey to specially equipped locations in the United States and overseas.

Environmental information is transmitted to operating naval forces by means of radio (telegraph, teletypewriter, facsimile, and voice) broadcasts. Products for these broadcasts are prepared by the Fleet Weather Centrals and Facilities and include observations, analyses, forecasts, and warnings. In preparing such products, the Centrals and Facilities make use not only of their own specialized products, but also—insofar as possible—products of the Basic Meteorological Service and other data as received from the weather teletypewriter networks of the FAA, the National and High Altitude Facsimile Networks of NOAA, and the Automated Weather Network (AWN) and teletypewriter systems of the Air Force.

In addition, the NAVOCEANO receives information from six teletypewriter weather circuits and two weather facsimile machines for synoptic data input to its Ocean Forecast Techniques Development Unit.

Communications are required to transmit marine data in relatively short time for a number of associated agency programs. The National Oceanographic Data Center (NODC) of NOAA operates a teletypewriter exchange service (TWX) data link with selected scientific institutions. This TWX service includes terminals at the Woods Hole Oceanographic Institution, the Scripps Institution of Oceanography, and the National Climatic Center (NCC), and at other activities.

In connection with its Pacific Tsunami Warning System, the National Ocean Survey (NOS) of NOAA required \$88,000 in FY 71 for communication purposes. These funds were used in partial support of a cooperative arrangement for data collection and watch-and-warning services using



Naval Environmental Data Network (NEDN)
—Conterminous United States

FAA, NASA, military, and other communication channels.

Coast Guard communications facilities are used for transmitting International Ice Patrol broadcasts, for reporting oceanographic and meteorological observations, and for broadcasting high-seas bulletins as reported earlier. Equipment includes teletypewriter, facsimile, and high-speed data links. In FY 71, communications for such Coast Guard activities amounted to \$357,000, including \$214,000 for construction of the facility at San Francisco, Calif.

DATA PROCESSING AND INFORMATION DISSEMINATION

Agency activities involving data processing and information dissemination functions are dealt with together in this section to present a more cohesive summary of the product generation services of MAREP. Facilities for such services are designed to accommodate the wide range of services required and to cope with the varied stages of development of observational and prediction techniques.

There are three major types of data processing centers—primary, area and guidance, and specialized. Primary centers are facilities which prepare general analyses and forecasts on a hemispheric or national basis for use by other centers. Area and guidance centers have analysis, forecasting, and warning responsibilities on an area, regional, or command basis and use primary center outputs, supplemented by their own processing functions, to provide detailed product services to users. Specialized centers provide data management or analyses, long-term predictions, or single-purpose services not available from other centers to specific users or user groups.

Information dissemination includes the distribution of local marine forecasts, advisories, and warnings; the operation of facilities engaged in the dissemination of these products; the provision of briefing services; the operation of visual display systems; and the delivery of data summaries, marine atlases, and results of special studies. The principal means for disseminating marine products to civil users are by commercial communications media (radio and television), government communications facilities (voice, radiotelegraph, teletypewriter, and facsimile broadcasts), automatic telephone-answering systems, and through various Government publication services.

The National Oceanic and Atmospheric Administration (NOAA) contributes significantly to marine meteorological predictions and warnings through its analysis and forecast centers and by

means of a variety of information dissemination capabilities. Communication facilities of the Coast Guard and the Navy as well as those of commercial facilities are used in the dissemination of marine meteorology products of NOAA. Currently available are forecasts of marine weather, sea state, breakers and surf, sea ice, storm surges, and seiches. The hurricane forecasting service also constitutes an essential element of the Basic MAREP Service.

NOAA operates four primary centers which provide products and support to marine meteorology in addition to their much larger roles in the Basic Meteorological Service. The National Meteorological Center (NMC) at Suitland, Md., provides broad-scale analyses and forecasts on a hemispheric basis and graphic products for facsimile transmission to high-seas users. The National Environmental Satellite Service (NESS), also at Suitland, operates the National Operational Meteorological Satellite System (NOMSS) to provide global cloud-cover mosaics and interpretive data on a daily basis. This System also provides direct local readouts of cloud cover pictures from weather satellites to suitably equipped shore stations and ships. The National Hurricane Center (NHC) at Miami, Fla., issues warnings of tropical cyclones (hurricanes) in the North Atlantic Ocean (west of longitude 35°W.), the Caribbean Sea, and the Gulf of Mexico. Forecast Centers in San Francisco and Honolulu provide similar services in the eastern and central North Pacific Ocean east of longitude 180°. In addition, warnings of severe local storms (thunderstorms and associated winds, hail, and tornadoes) over the conterminous States and coastal waters are issued by the National Severe Storms Forecast Center (NSSFC) in Kansas City, Mo.

Weather Service Forecast Offices (WSFO), operated by NOAA in the 50 States and Puerto Rico, provide analyses, forecasts, and warnings on a regional basis, including coastal areas and the Great Lakes, which contribute to the Marine Meteorological Service. Nineteen WSFOs issue forecasts and warnings for coastal waters; 14 other WSFOs provide similar services for inland lakes and waterways. Coastal area responsibilities are met by the WSFOs at Boston, New York City, N.Y., Washington, Raleigh, N.C., Columbia, S.C., Miami, New Orleans, La., San Antonio, Tex., San Juan, P.R., Los Angeles, San Francisco, Portland, Oreg., Seattle, Honolulu, and Anchorage, Alaska. The Offices at Boston, Washington, Miami, New Orleans, and San Juan issue limited forecast and warning services for fishing fleets operating in the North Atlantic Ocean (west of longitude 60°W.), the Caribbean Sea, and the Gulf of Mexico. Offshore and



Weather Service Offices Providing Marine Forecasts by VHF Radio (National Weather Service)

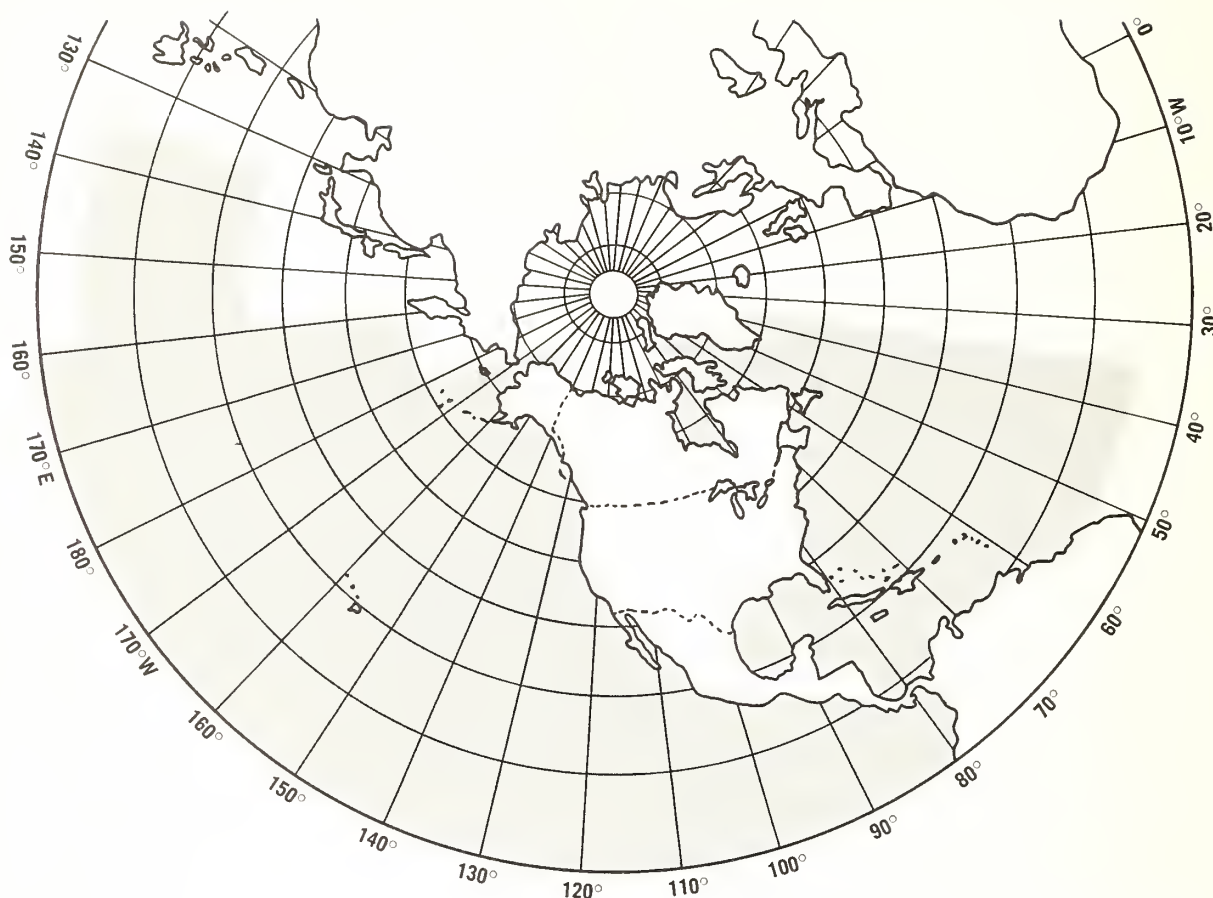
fishing activities in the Pacific Ocean are supported, in part, by the coastal and high-seas products provided for that area. Forecasts and warnings for the Great Lakes are issued by WSFOs at Chicago, Cleveland, Ohio, and Detroit, Mich.

High-seas marine condition forecasts, broadcast through Coast Guard radio facilities including facsimile, are to be initiated by NOAA in 1971 from the west coast. These forecasts will be in addition to those on radiotelegraph and voice broadcasts presently being disseminated through commercial facilities. Major WSFOs at Washington, San Francisco, and Honolulu provide support to meet the minimum analysis and forecasting requirements in the areas of U.S. responsibility for shipping forecasts and warnings (which includes large designated portions of the North Atlantic and North Pacific Oceans) as part of the Convention on Safety of Life at Sea (SOLAS) and in response to agreements reached within the World Meteorological Organization (WMO). In the western North

Pacific Ocean, the Department of Defense provides these services through the Fleet Weather Central at Guam in the Mariana Islands. The areas of U.S. responsibility are shown on the accompanying chart.

An example of an agency system designed to produce real-time predictions is the main computer processing component of the Naval Environmental Data Network (NEDN) which, through interconnected digital computers and on-line communications equipment, processes, disseminates, and displays meteorological and oceanographic analyses and forecasts on a hemispheric basis to meet Defense needs. With these facilities, the products are continually updated and tailored to fleet and other needs of Defense.

The Fleet Numerical Weather Central (FNWC) is a primary center which provides basic analysis and forecast products for the Northern Hemisphere in support of Defense requirements. The products of the FNWC are distributed through the NEDN

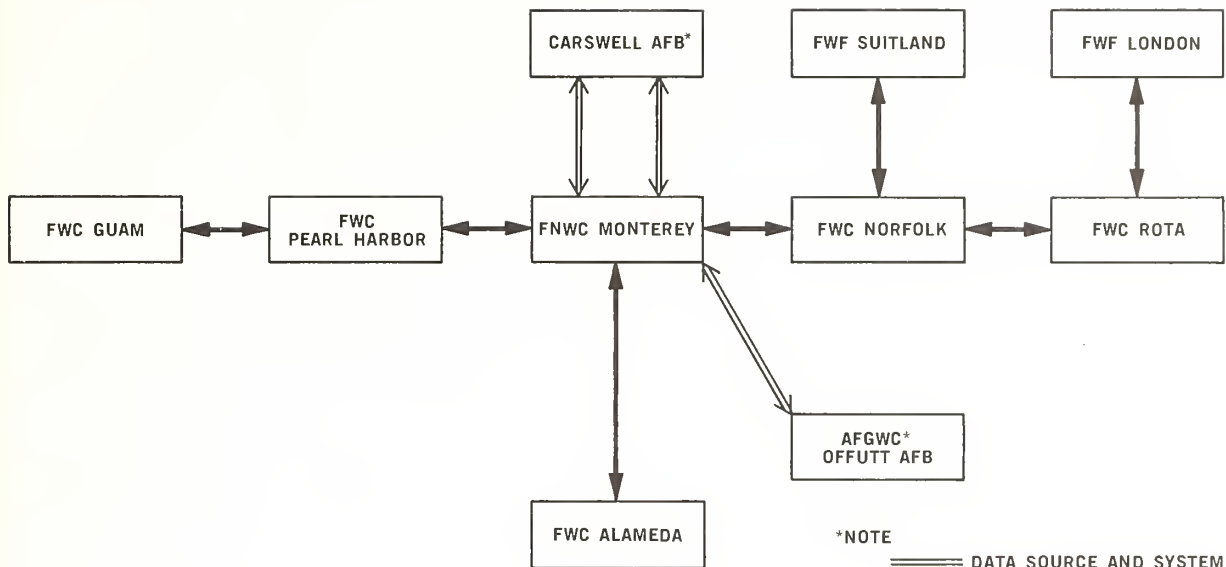


Areas of United States Responsibilities for Shipping Forecasts and Warnings under International Agreements

to Fleet Weather Centrals and Facilities strategically located throughout the world. The accompanying chart shows the terminals of the NEDN. The FNWC is the master center for collecting and processing worldwide data inputs. Responsibilities for providing fleet support throughout the oceanic regions of the world are shared by Fleet Weather Centrals at Guam, Pearl Harbor, Norfolk, and Rota. Computers at these Centrals receive processed data fields from the FNWC, augment these fields when received with later observational data, and produce environmental support products tailored for naval forces at sea and ashore. The Centrals use the broad-scale products from the FNWC and, where available and applicable, products from the NMC to prepare detailed analyses, forecasts, and warnings for their areas of responsibility. The Fleet Weather Central products are disseminated to naval operating forces and to smaller naval environmental units through the Naval Communications Systems.

More than 60 Weather Offices at shore stations and aboard larger ships provide MAREP Service in support of the Navy's operations. The focal point of the environmental support is at the operating level. The primary purpose is to support operational commanders by providing meteorological information and advice. Briefings generally are conducted in person but may also be provided by telephone or closed-circuit television.

Oceanographic observations are collected by regional centers and edited, cataloged, and transmitted through the NEDN to the FNWC for hemispheric analyses. Data are also forwarded to NAVOCEANO, Woods Hole Oceanographic Institute, Coast Guard, NMFS and NODC of NOAA, and Royal Navies of Canada and the United Kingdom for forecasting and support to research projects and for archiving. The FNWC performs hemispheric-scale oceanographic analyses and forecasts every 12 hours, using a complex forecasting model based on theoretical considerations, cli-



Naval Environmental Data Network (NEDN)
 —Overseas

matology, and empirical equations. These analyses and forecasts, discussed further under the MAREP Service for Specialized Military Applications, are made available to the Naval Weather Service Command activities engaged in immediate fleet support. The oceanographic products are distributed to users by a variety of communication systems, such as Fleet Broadcasts by means of radioteletypewriter or facsimile, digital data links, and non-electronic means.

The MAREP Services of the Coast Guard, in addition to participation in the Coastal Warning System discussed below, include voice and radioteletypewriter broadcasts of marine weather to the boating public, fishing vessels, and merchant fleets. The Coast Guard Oceanographic Unit processes data and provides technical and scientific support for Coast Guard marine programs. Coast Guard Air Stations provide forecasts and environmental services to support flight operations over marine areas. In addition, two Coast Guard Weather Offices function as specialized centers in support of search and rescue (SAR) operations at sea. These offices, located at the Maritime Search and Rescue Control Centers in New York City and San Francisco, provide advice to commanders directing rescue operations and prepare specialized forecasts for transmission to vessels, aircraft, and coordination centers engaged in SAR operations. The Coast Guard also provides preliminary reduction and processing of environmental data from all

of its sources at east and west coast centers to meet the requirement for operational continuity of its oceanographic programs.

The Coastal Warning System is a cooperative network of visual (flag and light) displays maintained at prominent locations along the seacoasts, the Great Lakes, and inland waterways to advise boating and other marine interests when small-craft, gale, storm, and hurricane warnings, issued by the National Weather Service (NWS) of NOAA, are in effect. Yacht clubs, marinas, and other private marine activities; State and local governments; and the Coast Guard and the NWS participate in this network of about 500 display stations. The Department of Transportation (Coast Guard) has 163 lighthouses, lifeboat stations, lightships, and other facilities participating in the Coastal Warning System. The Department of Commerce (NOAA) operates 75 displays; the remainder are operated in a cooperative basis by non-Federal interests. In addition, small-craft warnings are displayed by State police patrol craft in Chesapeake Bay, in the New York City area, and on Lake Michigan.

Included in MAREP are non-real time information services where the usual total sequence of functions, from data acquisition to product dissemination (particularly high-speed communications) which characterizes real-time environmental processing and predictions, are not always applicable. Such services include data management and publi-

cation of climatological atlases, tide and tidal current predictions, and long-term studies of effects on the environment of particular geographical regions.

The National Ocean Survey (NOS) of NOAA makes tide predictions—the times and heights of high and low waters resulting from astronomical tides—for 54 locations in the United States and its territories and possessions and for 39 stations in 18 different nations and in the Trust Territory of the Pacific Islands under U.S. jurisdiction. Predictions for approximately 6,000 secondary locations are computed through the application of empirical constants. Tide predictions, based on harmonic analysis of records of 29 days or longer, are made by computer and published annually in four volumes. The NOS also provides, but does not publish, tide predictions at seven additional foreign locations. The tide data are also analyzed for the harmonic constants used in predictions, in datum plane determinations, and in secular changes of the sea level. Tide analyses, using manual and computer techniques, cost \$334,000 in FY 71.

Tidal current predictions are made for 35 coastal and harbor locations in the United States. These predictions include times of slack waters and the times, speeds, and directions of maximum tidal currents. Empirical constants provide predictions at about 2,000 additional locations. Unpublished predictions of tidal currents for two Korean stations are provided to that Nation. Charts showing the areal distribution of tidal currents for each hour in the tidal cycle are available for nine major U.S. harbors and estuaries; charts are under construction for additional estuaries. Processing—including the summarizing, analyzing, and harmonic predicting of tidal currents by mechanical and computer techniques—cost \$77,000 in FY 71.

Publication and distribution of documents produced by the NOS cost \$281,000 in FY 71. Such publications include four tide tables and two tidal current tables published annually, two temperature-density tables produced every 5 years, tidal benchmark sheets, 11 tidal current charts, and other information issued in response to special requests during the year.

The Pacific Tsunami Warning System, operated by NOS, involves coordination of activities at several administrative and governmental levels and a complex range of responsibilities. The Warning Center is at Honolulu where data are received from a network of 22 seismographic stations and 44 tide stations, where analyses and warnings are formulated, and from where warnings are disseminated to 15 countries and territories in the Pacific Ocean Basin. The accompanying chart shows the

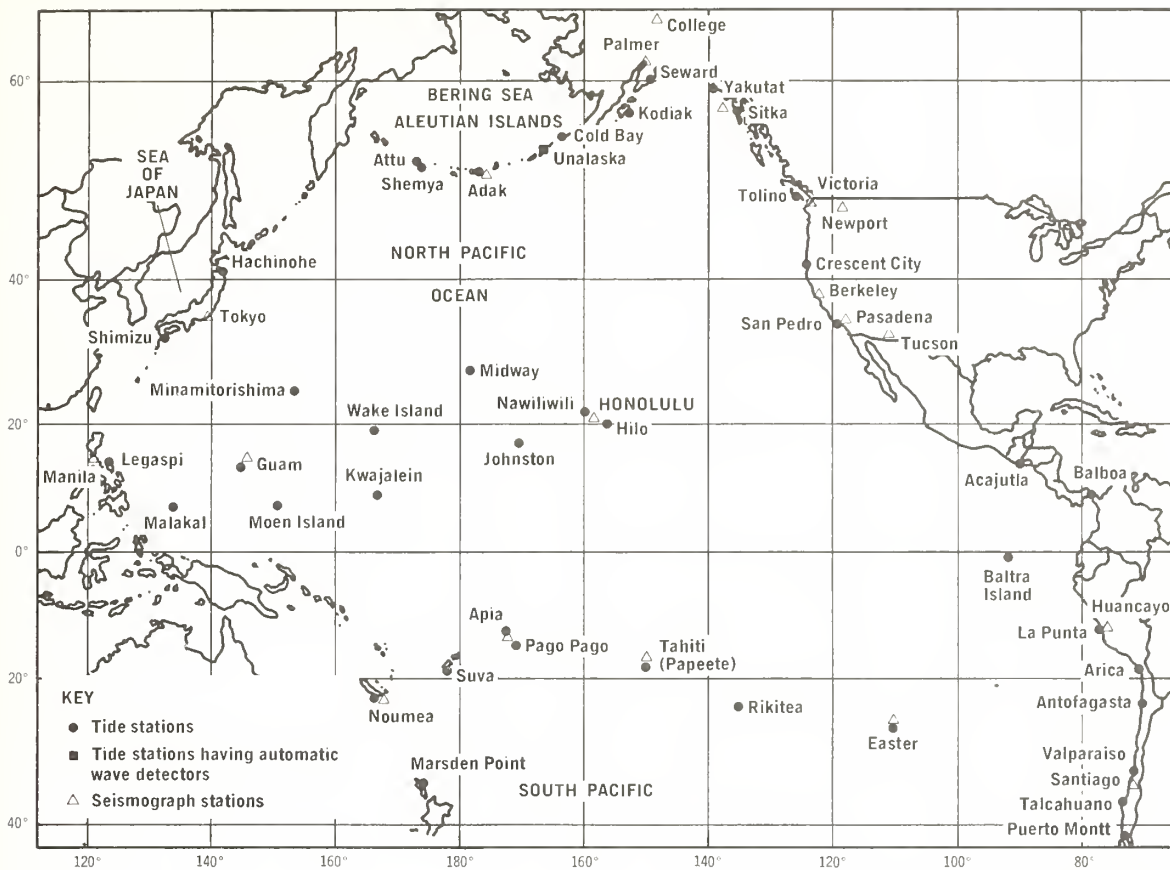
stations in the System. Processing of earthquake data for possible tsunami warnings cost \$40,000 in FY 71.

The Pacific Tsunami Warning System required \$322,000 for internal support in FY 71. These funds support staffs at the Honolulu Observatory, the International Tsunami Warning Center, and the Pacific Tides Party in Hawaii and at the Palmer Warning Center in Alaska. Staffs at NOS Observatories at College and Sitka, Alaska; Newport, Wash.; Tucson, Ariz.; and Guam are also funded. These staffs provide continuous monitoring of seismic and tsunami activity; install, maintain, and service the instruments; locate earthquakes; activate the warning system; issue watches, warnings, and cancellations; and provide historical and advisory scientific information.

The National Oceanographic Data Center (NODC) acquires, processes, stores, and disseminates non-real-time data involving geophysical, chemical, geological, and other selected oceanographic parameters on a global basis. These data are used by the scientific community for the development of models and for the upgrading of such models to produce or to complete a description of the oceans. All data and information received by the Center are given an accession number and then processed into files and storage media for quick retrieval. Using its Generalized Information Processing System (GIPSY), the NODC can provide 48-hour turnaround time for routine requests. New data management techniques for improved processing are being developed for data compression, file structure, analog-to-digital conversion, and use of optical-scanning methods.

The NODC provides data and data products from storage files to the total spectra of users in the national marine community and in response to international exchange agreements. Services include, but are not limited to, the provisions of listings, tapes, microfilm, statistical and analytical summaries, computer graphics, charts, and atlases. In FY 71, product dissemination of NODC cost \$302,500.

The National Climatic Center (NCC) at Asheville, N.C., also a specialized data center, is responsible for the processing, archiving, and retrieval of marine climatological data, including reports from naval and merchant vessels, on a reimbursable basis for other agencies and private concerns. The NCC is responsible for recording and describing the climate of the oceans in support of national requirements. Ship weather logs are received at the NCC from about 2,100 merchant vessels each year. Observations entered in these logs are checked, re-



JUNE 30, 1970

Reporting Stations of the Pacific Tsunami Warning System



Multiperspective X-Y Printer (National Oceanographic Data Center)

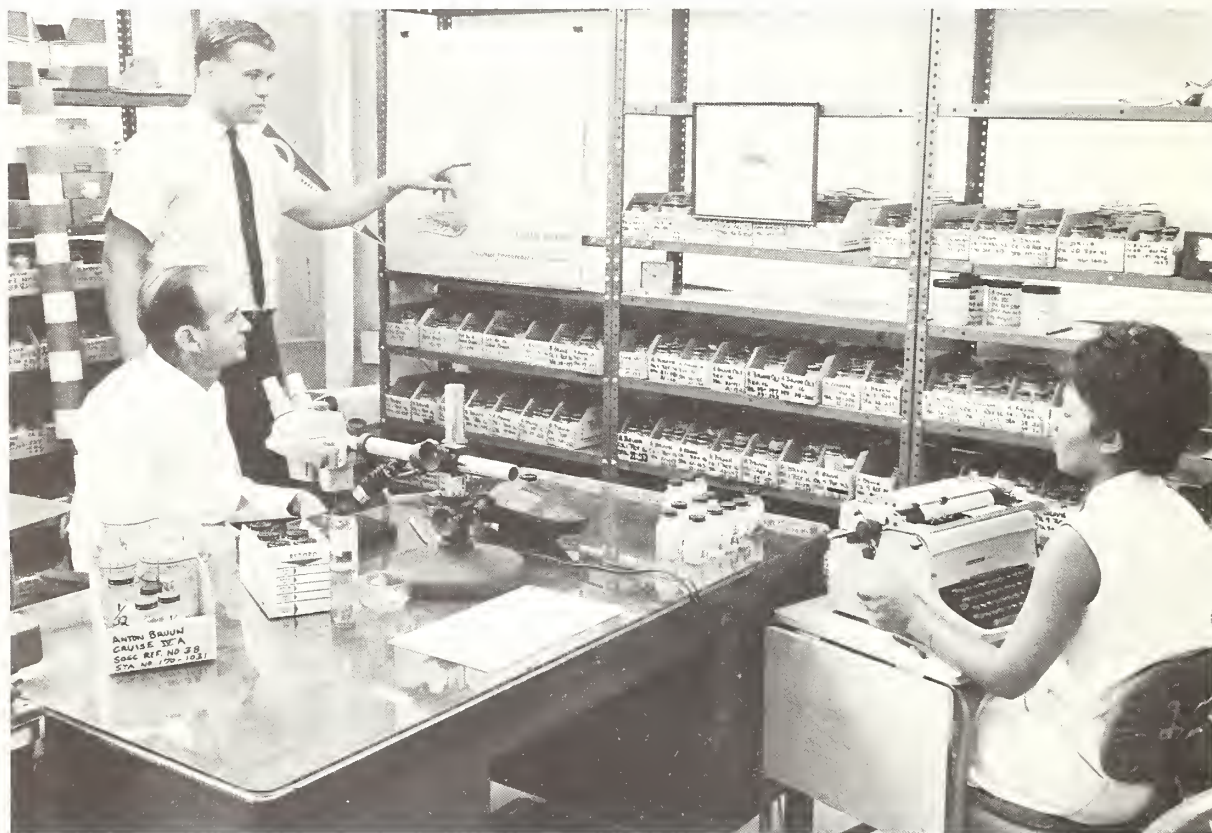
corded, summarized, and archived. Summaries are included in various Commerce, Coast Guard, Defense, and WMO publications. In addition, as part of a WMO program, marine observations are exchanged with other major maritime nations and summaries of observations by Ocean Station Vessels are provided. Defense provides a large share of budgetary support to the NCC. At a cost of \$200,000 in FY 71, the Navy compiled and published the revised *Marine Climatic Atlases* and the detailed operating-area atlases. Nonreimbursable operating funds for processing by the Center amounted to \$110,000 in FY 71.

NCC also provides summarized marine meteorological data to private, public, academic, and governmental users. It is responsible for publication of the *Mariners Weather Log*, Pilot Chart revisions for Defense, articles and climatological summaries for Defense *Sailing Directions* and *Planning Guides*, and *Coast Pilot* of the NOS. The Marine Branch of the Center also has the responsibility for publishing the climatology of tropical cyclones on a worldwide scope and is involved in the publication of tropical cyclone summaries and in the answering

of requests for data and other information on such storms. Nonreimbursable expenses for dissemination of MAREP-related information in FY 71 amounted to \$66,000.

The Great Lakes Regional Data Center (GLRDC) of NOAA's National Ocean Survey has a program directed toward processing, storage, retrieval, dissemination, and analysis of hydraulic and hydrologic, limnological, hydrometeorological, and ice and snow data. Such data are used extensively in research in fisheries, pollution, shore processes, currents, and ice formation and movement in the Great Lakes.

Operating as part of the Smithsonian Institution's Office of Oceanography and Limnology, the Smithsonian Oceanographic Sorting Center (SOSC) provides a service function for coordinating and processing collections of marine specimens to expedite their rapid analysis. This function, which includes the sorting, cataloging, and distribution of marine biological and geological collections, cost \$300,000 in FY 71 and is funded, in part, by the NSF through its Office of Polar Programs.



The Smithsonian Oceanographic Sorting Center, Washington, D.C.

The Army Corps of Engineers of the Department of Defense conducts a number of projects, categorized as specialized processing of marine environmental data, in connection with its assigned marine engineering studies. In support of basic and applied hydraulic and hydrologic studies are the development of stage-discharge relationships in outflow rivers and the determination of the effects on the levels and outflows of the Great Lakes of such factors as natural and manmade changes in the outflow rivers, diversions into and out of the Great Lakes Basin, and fluctuations between the Lakes. General hydrologic studies involve the analyses of rainfall-runoff relationships, snowmelt studies, flood forecasting, analyses of past floods, infiltration indices, and unit hydrographs, as well as the development of flood hydrographs and other studies related to hydrology. The NWS of NOAA prepares meteorological studies required by the Corps for the planning, design, and operation of water control structures.

The Corps of Engineers is providing technical services on request to States and local governments that cost \$525,000 in FY 71. These services constitute furnishing information on the use of flood plains of the coastal zone.

The Department of the Interior analyzes and processes data collected at estuarine and coastal stations by the U.S. Geological Survey (USGS) in support of its projects in hydrology and hydraulics. The USGS also provides data on stream discharge and water quality which are processed in its own Computer Center Division. It supplies water quality information to the Stret System operated in cooperation with the Water Quality Office of EPA. These data are available to all users.

GENERAL AGENCY SUPPORT

General agency support is the function that covers activities which agencies must perform to operate efficient MAREP Service programs and to provide effective, reliable support to their users. This function includes training, maintenance, internal support, and management above the operating level.

Training in marine observations, communications, maintenance, and similar technician-level skills is accomplished in schools operated by the Federal agencies; professional-level training is obtained at accredited colleges and universities. Training costs include instructor and student pay, equipment, travel, books, and tuition.

Accurate sea, swell, surf, storm surge, and other marine forecasts require adequate training in physical oceanography and in meteorology. Although

the National Weather Service (NWS) forecasters currently supporting civil marine users are qualified meteorologists, only a few have received formal oceanographic training. Selected Department of Commerce meteorologists are now receiving this training in university programs.

The major portion of the Federal training effort in support of MAREP is performed by the Department of Defense. Technician-level training is conducted in military and naval service schools. The Naval Postgraduate School at Monterey has an Environmental Sciences Program to qualify commissioned officers as oceanographers and meteorologists through advanced degree studies and independent research. A few officers from the other military services as well as officers from selected foreign countries also attend. A limited number of naval officers are also selected for advanced degree studies at civilian universities.

Regional centers perform an important task in the training and indoctrination of Naval Weather Service Environmental Detachment officers and of mobile oceanographic teams. Another important training function, performed by the Naval Weather Service Command (NWSC), is the indoctrination of fleet antisubmarine warfare operators in the tactical application of oceanographic predictions. Ice observers are trained at the Naval Oceanographic Office (NAVOCEANO). This Office also sends selected scientists to universities for advanced training in oceanography, mathematics, computer science, and other disciplines which will enhance their contributions to projects having an application to MAREP. Naval officers from other nations are trained at NAVOCEANO in forecasting and analysis techniques of the Antisubmarine Warfare Environmental Prediction System (ASWEPS), to enable these officers to establish prediction programs in support of their naval operations.

As part of the Naval Technical Training Center, three levels of meteorological technician training are conducted for enlisted personnel at Lakehurst, N.J.; this Center provides specialized technical training in meteorology and oceanography. Small numbers of personnel from the Coast Guard and other military services are accommodated.

A Meteorological and Oceanographic Equipment Maintenance (MOCEM) course for Electronics Technician (ET) personnel was established at the Naval Air Technical Training Center at Lakehurst in 1969. This Center is the site of an ET school with a duration of 17 weeks where personnel are trained in the maintenance of shipboard, airborne, and land station equipment designed for measuring marine parameters.

Coast Guard personnel receive advanced training at Navy schools to support Coast Guard participation in the Basic Meteorological Service observational program and to meet Coast Guard requirements. Basic meteorological training is conducted specifically as a part of the Marine Science Technician Service School curriculum. The Coast Guard also supports postgraduate training in oceanography at several universities and provides an ocean sciences major within the curriculum of the U.S. Coast Guard Academy.

Maintenance costs cover those measures taken to keep equipment in proper operating condition and to repair such equipment when it fails. Included are salaries and travel expenses of maintenance personnel, funds to furnish test equipment, and monies to purchase spare or replacement parts for meteorological and oceanic-sensing equipment. Maintenance costs for communications systems are included in the cost figures for programs reported earlier. Maintenance is performed in central overhaul facilities and in regional shops. The largest portion of the maintenance effort is accomplished at the local level where emphasis is placed on preventive maintenance and on swift emergency actions to restore vital facilities to operation.

Routine maintenance of meteorological and oceanographic equipment in the Navy is a command responsibility, and maintenance is provided for by the local organization, that is, the ground electronics shop at shore activities and the electronics division aboard naval vessels. To provide support for field commands and ships, a Meteorological and Oceanographic Equipment Program (MOEP) has been established to assist in the handling of chronic maintenance problems and installation planning. This Program is a responsibility of the NWSC and consists of specialty training officers, civilians, and enlisted personnel.

Commerce maintenance programs in meteorology are operated and funded as a part of the Basic Meteorological Service. Maintenance of other equipment by the several activities of NOAA is funded under other functional categories discussed earlier.

General mission-related activities in support of MAREP operations within an agency include the following types of programs:

- Engineering support for planning, preparing specifications, surveying equipment sites for suitability, and inspecting and calibrating new equipment.
- Scientific studies and consultant services to determine the feasibility of new programs and to increase the effectiveness of on-going programs.

- Quality control of products to assure that accuracy and productivity standards are maintained.
- Employee housing and housekeeping or utility-type equipment at remote-area locations.

Internal support activities within Commerce are consolidated in a large part under the Basic Meteorological Service and are provided by staff elements of the NWS of NOAA and its Regional Headquarters, when necessary, for specialized marine user programs. Executive management, supervision, administration, planning and logistical support provided from above the operating unit level to support MAREP Services is accomplished within Commerce by full- or part-time marine specialists in the various components of NOAA.

Internal support activities within the Navy include: technical support provided by the Naval Weather Service Command and the Naval Air Systems Command; engineering support provided by Naval Industrial Management Offices and Public Works Offices; and management, supervision, administration, and logistical support provided at the local operating level. Management above the operating level within the Navy is provided by a part of the staff effort at the Office of the Oceanographer of the Navy, the NWSC, the Naval Air Systems Command, and the NAVOCEANO.

Executive management and supervision of the marine sciences operations of the Coast Guard is accomplished by Headquarters and Area personnel who oversee oceanographic endeavors and provide liaison with other agencies and the scientific community.

PLANS FOR SERVICE IMPROVEMENT OPERATIONAL PROGRAM

The FY 72 operational program for the Basic MAREP Service reflects an overall increase of \$2,015,000 from FY 71. A number of programs planned for FY 71 have been carried over into FY 72 because of budget restraints. Conversely, some programs have been reduced because of the completion of facility construction or expansion and other nonrecurring expenses funded through FY 71 or because of the curtailment of services.

The FY 72 increases are programmed to support the continuation and expansion of existing MAREP services by providing replacement equipment, taking certain personnel actions, modifying or improving facilities required to support such services, and providing for new and added improvements in the services. Significant areas in which improvements and new MAREP services are planned are as follows:

- Expansion of NOAA's marine weather and sea forecast and warning services to a variety of marine activities by the establishment of a Marine Forecast Unit at San Francisco. (Increased funding totalling \$150,000 will permit a continuous watch over the eastern North Pacific Ocean.)
 - Expansion of the facilities of the National Environmental Satellite Service (NESS) for acquisition and processing of oceanic data (including mapping of sea-surface temperature and ice to a finer scale) in support of prediction functions, at an increased cost of \$1,450,000.
 - Expansion of the capabilities of the National Oceanographic Data Center (NODC) of NOAA, requiring \$400,000 in new funds to be used by the Center for processing the increased volume of biological, geological, and XBT data; for supporting the development of projects on information systems, live atlases, and data compression techniques; for expanding the present computer capability; and for providing dissemination services to the user community through an expansion of microfilming, publication and form printing, and indexing services.
 - Improvements in observations for the Pacific Tsunami Warning System of NOAA, costing \$25,000 for satellite data collection.
 - Acquisition of equipment by the National Ocean Survey of NOAA, at a cost of \$100,000, to expand its tide-measuring network.
 - Increased funding of \$575,000 to be used by Defense for installing XBT equipment on additional ships of opportunity, naval vessels, and new observation vessels.
 - Equipping of scheduled follow-on Navy reconnaissance aircraft with additional oceanographic sensors, costing \$346,000.
 - Implementation of revisions to *Marine Climatic Atlases* and continued publication of detailed operating-area atlases by the Navy, requiring \$76,000 in new funds.
 - Development of stage-discharge relationships in outflow rivers and determination of effects on the levels and outflows of the Great Lakes by the Corps of Engineers, requiring \$36,000 in new funds.
 - Expansion of the Permit Management Program of the Corps of Engineers to evaluate the impact of all discharges into the Nation's navigable waterways so as to protect the ecosystems in the coastal zone.
 - Expansion of the environmental data collection program of the Corps of Engineers to improve baseline data for engineering analysis in the planning, design, construction, operation, and maintenance of projects through the use of remote-sensing techniques.
 - Expansion of USGS network of stream-gauging stations and water quality observation points in coastal areas as permitted in Federal-State Cooperative programs.
 - Improvement of knowledge of the tidal hydraulics and the general coastal environment in the Arctic region of Alaska by the Corps of Engineers at a cost of \$76,000.
 - Improvement in technical services to States and local governments by the Corps of Engineers, costing an additional \$45,000.
 - Increase in the capabilities for collecting oceanographic data from Ocean Station Vessels, Standard Monitoring Sections, and other Coast Guard vessels, costing \$375,000.
 - Expansion of the Smithsonian Institution program in collection of marine biological data in FY 72 at an anticipated increased cost of \$100,000.
 - Expansion of processing services performed by the Smithsonian Oceanographic Sorting Center (SOSC) at an additional cost of \$100,000.
- Principal decreases in FY 72 funding for the Basic MAREP Service have resulted from the following circumstances:
- Completion of the high-seas broadcast portion of the Coast Guard marine radio station at San Francisco.
 - Completion of the installation of salinity-temperature-depth (STD) sensors on major Coast Guard vessels.
 - Reduction of several weather and oceanographic offices to conform with Department of Defense base closure decisions.
 - Reduction in funds for Navy postgraduate training in oceanography.
 - Significant decreases in Department of Defense Basic MAREP data acquisition expenditures.

RELEVANT RESEARCH PROGRAM

Research programs in support of the Basic MAREP Service are funded principally by the Department of Commerce and the NSF. Smaller programs in terms of funding are conducted by the Departments of Defense, Interior, and Transportation and by the AEC, NASA, and the Smithsonian Institution.

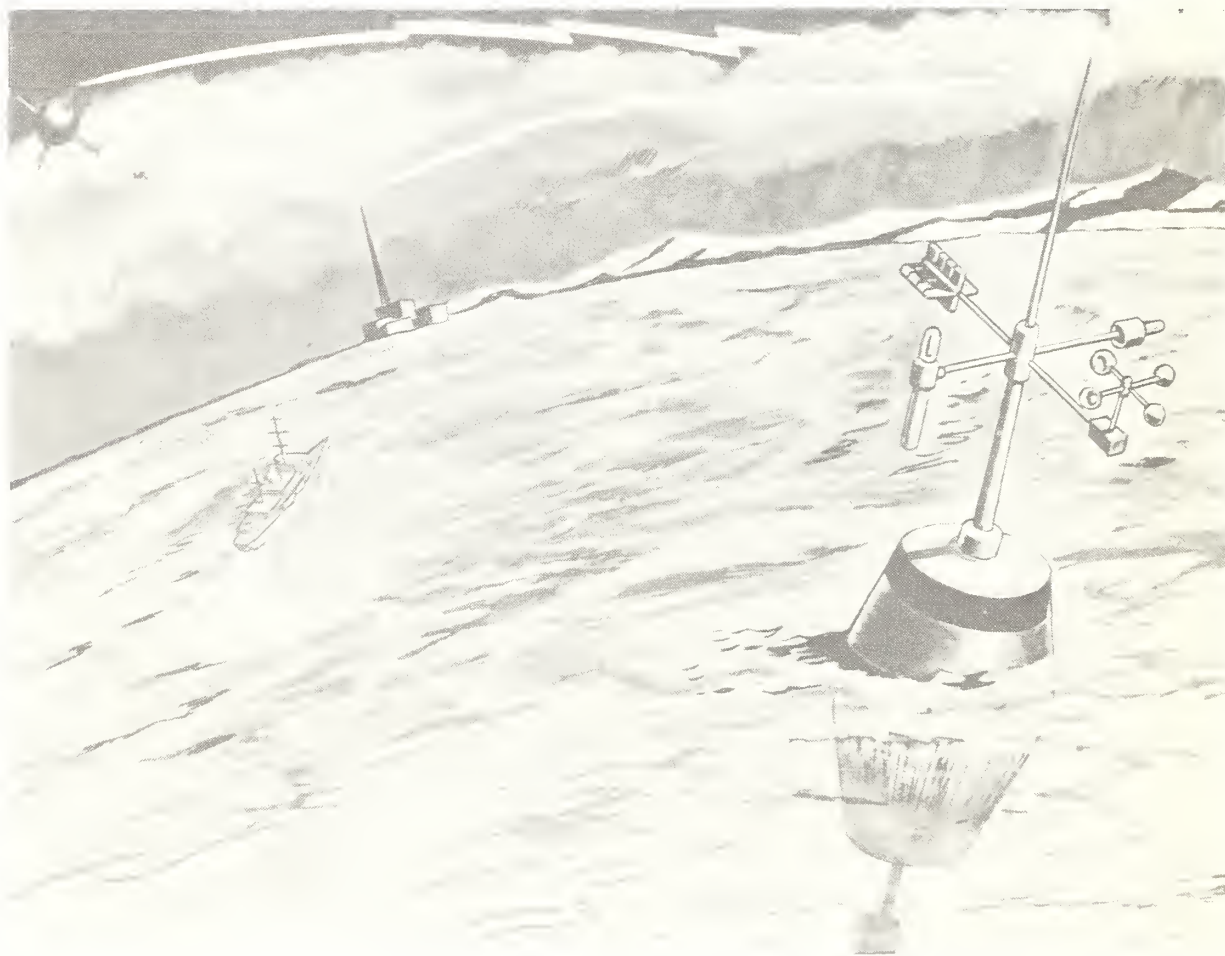
The National Data Buoy Project (NDBP) of NOAA, funded at \$13,000,000 in FY 72, is the largest single research and development project in support of MAREP. The accompanying diagram shows the concept for the National Data Buoy System. The NDBP was established, initially under the direction of the Coast Guard, to develop and implement the national networks of unmanned telemetering environmental buoys preparatory to a future decision on deploying an operational system.

The deployment of prototype (pilot) oceanographic and marine meteorological data buoys by the NDBP is identified and discussed in the report of the Commission on Marine Sciences, Engineering and Resources, *Our Nation and the Sea*. Central to the development of a buoy network is the compilation and analysis of all national requirements, including environmental studies; the analysis of costs, benefits, and trade-offs; and the devel-

opment of improved equipment for reliable, accurate, unmanned buoy operations.

The advanced development effort will continue in FY 72 and consist of three major efforts: (1) deployment, testing, and evaluation of Engineering Experimental Phase (EEP) buoys developed during FY 72; (2) specification and contract award for preprototype buoy components having reliability and performance requirements as design goals for the prototype network buoys; and (3) specification and contract award for drifting and moored low-capability buoys to be deployed in July 1972 for the testing of their role in a future National Data Buoy System.

NOAA conducts a number of other research and development projects which support the Basic MAREP Service through improvement of prediction techniques or through acquisition of basic knowledge of those marine processes having poten-



National Data Buoy Systems Concept

tial application to marine prediction programs. These efforts include development of sensors and prediction techniques; studies of air-sea interaction, sea-surface phenomena, ocean dynamics, tsunami runup effects, storm surge, and Great Lakes limnology; and participation in large national and international cooperative investigations. These international investigations include:

- ☐ The Tropical Atlantic Experiment of the Global Atmospheric Research Program (GARP).
- ☐ The International Field Year for the Great Lakes (IFYGL).
- ☐ The Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR).

In addition, following completion in FY 70 of the Barbados Oceanographic and Meteorological Experiment (BOMEX), a project was established and is being continued to analyze the collected data. All

of the above-mentioned projects provide data for the basic understanding of the marine environment.

NOAA's National Oceanographic Instrumentation Center (NOIC) has responsibility for testing and evaluating oceanographic instrumentation, establishes calibration techniques and secondary reference standards, and disseminates information on instrument performance and development programs. In FY 72, NOIC will improve its support services to MAREP by replacing instrumentation for testing and calibrating equipment used for collection of oceanic data, at an increased cost of \$150,000.

In the Department of Defense, research programs relevant to the Basic MAREP Service are supported by the Corps of Engineers, through its Civil Works Program. Areas of investigation include coastal ecology, aquatic plant control, envi-



B-57 Aircraft Instrumented for Storm Research
(Environmental Research Laboratories of
NOAA)

ronmental data collection, wind waves, shore processes, and dynamics of flow through inlet and estuarine regions.

All military research programs are designed to meet the needs of the Department of Defense and are reported in the MAREP Service for Specialized Military Applications section appearing later in the Plan. It should be recognized, however, that the Basic MAREP Service benefits substantially from this Defense research effort. An example of such research with a potential relevance to the civil interests is the Ocean Acre study which is sponsored by the Navy. The objective of this study is to determine the acoustic and biological characteristics of the deep-scattering layer in a 60 nautical mile square column of water in the deep ocean. The study, initiated by the Navy Underwater Systems Center, coordinates the employment of expertise of that Center with those of the Smithsonian Institution, the NAVOCEANO, and the Graduate School of Oceanography of the University of Rhode Island.

The Department of the Interior sponsors research relevant to the Basic MAREP Service through the U.S. Geological Survey (USGS) which conducts investigations and research, partly in-house and partly in cooperation with States and other agencies, and through outside contracts. This work includes estuarine hydraulics, changes in water quality, sediment transport and deposition, thermal dispersion and its effects, use of remote-sensing techniques, salt-water intrusion and underground encroachment, tidal discharge, relation of streamflow to salinity, and effects and distribution of wastes introduced into coastal water bodies.

The Department of Transportation supports Coast Guard oceanography projects, including investigations of Arctic and Antarctic water masses, coastal studies, and ship support to university and other governmental activities such as the NDBP of NOAA and several environmental data buoy projects of the Navy.

A portion of NASA's support for spacecraft oceanography is relevant to the improvement of the Basic MAREP Service. This research is part of the Earth Resource Survey Program, conducted through the U.S. Naval Oceanographic Office (NAVOCEANO) Spacecraft Oceanography (SPOC) Project—under NASA sponsorship—and through the National Environmental Satellite Service (NESS) of NOAA. Specific projects which support Basic MAREP Service include sea-surface temperature surveys, ocean color investigations, ground-truth support, sea-ice and sea state, multi-

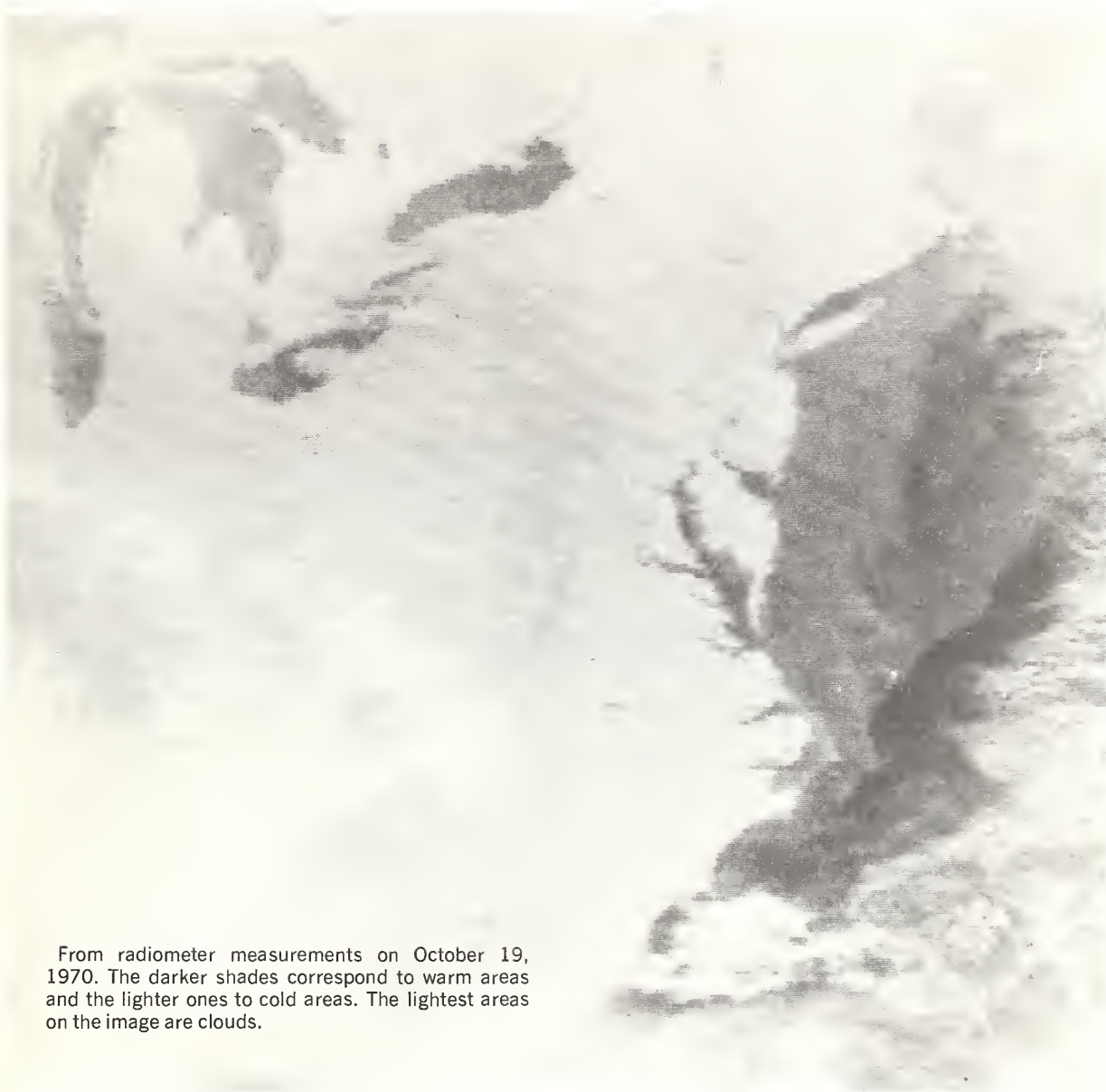
spectral ocean photography and image enhancement, and identification of shallow water features; administration and technical support are also given. The mission of the meteorological program of NASA is to develop and improve space technology in both satellite and sounding-rocket systems for use in exploring, understanding, and defining the structure of the atmosphere and for use in predicting its behavior, with particular emphasis on the operational application for marine areas and over landmasses.

During 1972, NASA will launch the first in a series of Earth Resources Technology Satellites—designated ERTS-A—primarily to survey land areas; however, its data will also provide information on coastal processes, shallow water bottom features, sea-ice conditions, and other ocean phenomena. NASA has plans also to fly ERTS missions dedicated primarily to the survey of the world's oceans in 1974 and 1975.

The AEC supports research related to the Basic MAREP Service through the development of a capability to document, evaluate, and understand explosion-generated water waves resulting from nuclear detonations at or near the surface of the ocean. On-going efforts include the development and maintenance of the sensor, recording, and readout systems to measure and document explosion-generated waves and the initiation of theoretical studies relating to the shoaling phenomenology of such waves. Other activities are concerned with investigations required to predict and document the effects of a water wave resulting from seismic activity caused by a nuclear explosion.

The NSF support to basic research in oceanography and meteorology and to research ship operations contributes heavily to an understanding of the marine processes. Results from these research programs are expected ultimately to enhance the Basic MAREP Service, although it is conceivable that one or more Specialized MAREP Services will also benefit. The relevant research programs fall into four categories: (1) ocean currents and water masses, (2) air-sea interaction, (3) mathematical modeling and fluid dynamics, and (4) biological oceanography. The NSF sponsors programs in these categories under the Scientific Research Project Grants, the Office of Polar Programs, the International Decade of Ocean Exploration (IDOE), the National Center for Atmospheric Research (NCAR), the Global Atmospheric Research Program (GARP), and the Interdisciplinary Research Relative to Problems of our Society (IRRPOS).

Research, contributing ultimately to long time-scale predictions of the Basic MAREP Service, is



From radiometer measurements on October 19, 1970. The darker shades correspond to warm areas and the lighter ones to cold areas. The lightest areas on the image are clouds.

Thermal Imagery of the Gulf Stream from ITOS-1 (National Environmental Satellite Service)

sponsored in estuarine ecology and tropical marine ecology by the Smithsonian Institution. These investigations are conducted at the Institution's Chesapeake Bay Center for Environmental Sciences and at the Smithsonian Tropical Research Institute. In its effort to examine the impact of

man on the environment, Smithsonian will expand the research program at the Chesapeake Center for Environmental Studies. In addition, the program at the Tropical Research Institute will be increased to assess the potential consequences of building a sea level canal.

Marine Environmental Prediction Service for Maritime Navigation

DESCRIPTION OF SERVICE

Many Federal operations in marine environmental prediction (MAREP), because of their applicability to a number of users and because of their support to other Specialized MAREP Services, are included as integral parts of the Basic MAREP Service; yet their particular significance to maritime navigation is apparent. Nearly all marine forecasts, advisories, and warnings produced under the Marine Meteorological Service are of importance and of direct application to navigation. The shipping industry, fishing fleets, and recreational boatmen use these products mainly for the protection of life and for the altering of ship tracks so as

to minimize damage to vessels and cargo and to effect optimum transit between ports. Elements of the Basic MAREP Service of importance to maritime navigation include sea-and-swell forecasts, storm surge and seiche forecasts, tropical and extra-tropical storm forecasts, and studies of sedimentation in channels and harbors. Also of primary importance are marine atlases, sailing directions, tide and tidal current prediction tables, and other special publications. Conversely, nautical charts, navigational tables, periodic navigational publications, and electronic navigation materials are not considered to be part of these MAREP Services; consequently, they are not included in this Plan.



Great Lakes Ore Carrier Penetrating Ice Pack

MARINE ENVIRONMENTAL PREDICTION SERVICE FOR MARITIME NAVIGATION, BY AGENCY

(in thousands of dollars)

	Operations		Relevant research		Total	
	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72
Defense	3,056	2,812			3,056	2,812
Transportation	876	807	251	762	1,127	1,569
NASA			230	230	230	230
Total	3,932	3,619	481	992	4,413	4,611

Programs of the Departments of Defense and Transportation which uniquely serve the specialized requirements of a MAREP Service for Maritime Navigation include those concerned with ice forecasts and warnings, and with ship-routing and channel maintenance services.

Perhaps the best known MAREP service of the Coast Guard is its management and operation of the International Ice Patrol, established by the maritime nations of the Inter-Governmental Maritime Consultative Organization (IMCO) to advise shipping of the ice menace in the northwestern North Atlantic Ocean. Aircraft reconnaissance and shipboard oceanographic observations support a program of reporting icebergs that enter the shipping lanes near the Grand Banks of Newfoundland and of predicting the drift of these icebergs. In FY 71, the International Ice Patrol activities of the Coast Guard cost \$683,000.

Other Coast Guard activities, reported under the Basic MAREP Service, contributing to the MAREP Service for Maritime Navigation are the environmental analyses and forecasts which support the flight operations and the operation of two small specialized centers which support the Coast Guards' Maritime Search and Rescue Control Centers in New York City and San Francisco.

The Department of Defense maintains a capability for sea-ice observations and forecasts by flying BIRDSEYE and fleet ice reconnaissance aircraft flights over the Arctic icepack and by providing observers for aerial ice reconnaissance of the Arctic and the Antarctic regions. In FY 71, Defense spent \$865,000 in ice observations. Experimental interpretations are also made of ice features from satellite photographs, and 15- and 30-day ice forecasts are prepared for the Arctic and Antarctic in support of operations by Defense, the Coast Guard, and NSF.

The Fleet Weather Facility at Suitland provides specialized ice forecasting services and the Fleet Weather Centrals at Alameda, Norfolk, and Guam

operate the Navy's Optimum Track Ship Routing (OTSR) Program. OTSR offers a high probability of one or a combination of the following: (1) least steaming time en route; (2) best weather route; and (3) bypassing of areas where storm damage may be expected. This service is available to naval ships, Military Sea Transportation Service (MSTS) ships, and vessels under contract to the Government. The Navy's OTSR Program provided routing services to approximately 2,400 ships for the Department of Defense during 1970. Major processing activities of the Department of Defense provide over 3,000 separate oceanographic prediction products daily to meet existing requirements. As technology progresses and data acquisition becomes adequate, the number and type of products increase and the modes of product application also expand.

PLANS FOR SERVICE IMPROVEMENT OPERATIONAL PROGRAM

There are no plans for increased funding by the Departments of Transportation and Defense in FY 72; however, there are continued plans for improvement and expansion of the specialized MAREP Service for Maritime Navigation through more efficient utilization of existing resources. It should be understood that the Coast Guard's expenditures in support of the International Ice Patrol depend on actual costs incurred (\$683,000 in FY 71) which could conceivably increase or decrease during FY 72.

The Department of Commerce will establish in FY 72, as part of the Basic MAREP Service, a Marine Forecast Unit at San Francisco which will primarily serve mariners in the eastern Pacific and along the west coast. The products will be prepared by NOAA's Marine Forecast Center and National Meteorological Center (NMC); product dissemination will be accomplished by radiofacsimile, voice, and radiotelegraphy from the new Coast Guard communication facility near San Francisco.

RELEVANT RESEARCH PROGRAM

Research programs in support of the specialized MAREP Service for Maritime Navigation are currently sponsored by the Department of Transportation and by NASA.

The Coast Guard, through its Oceanographic Unit and Office of Research and Development, conducts studies of water mass exchange and currents affecting the occurrence and distribution of sea ice and icebergs in the Grand Banks of Newfoundland and in Arctic regions. This research, totaling \$651,000 in FY 72, shows an increase of \$500,000 over FY 71, the largest portion of this increase will be expended on a sea-ice reconnaissance

research program, using side-looking airborne radar that is under development and endeavoring to make field tests that enhance the capability to locate, identify, and classify sea ice and icebergs. These radars will not only improve International Ice Patrol services, but will assist Coast Guard operations in the Arctic and in the Great Lakes. In case of the latter region, a principal goal is the development of a capability to extend the present safe navigation season to its greatest practicable extent. Another Coast Guard research and development program, designed to improve its capabilities to perform search and rescue (SAR) missions, involves the investigation at sea of the response to wind, waves, and currents of various boat hulls, rafts, and lifesaving devices.

The Corps of Engineers, through its Cold Regions Research and Engineering Laboratory (CRREL) at Hanover, N.H., investigates engineering problems associated with the Arctic ice cover. These investigations include an understanding of ice fracture patterns, physical properties, and driving forces as they relate to structures; an improve-

ment of bathymetry charts and remote techniques for measuring ice thickness which are required for ship routings; and a means for detecting ice-surface roughness and effects of extreme wind velocities, both of which affect the operation of air cushion vehicles.

The Office of Naval Research (ONR) sponsors three projects which are concerned with understanding the Arctic environment and ice cover for a number of naval applications, including navigation. Much of the field support for these efforts is obtained through the Navy's Arctic Research Laboratory (ARL) at Point Barrow, Alaska. Funds for these projects are reported under the Basic MAREP Service in this Plan because of their general applicability.

NASA, through the Spacecraft Oceanography (SPOC) Project operated by the NAVOCEANO, sponsors research projects which are designed to improve capabilities in the MAREP Service for Maritime Navigation. These projects involve investigations of ocean dynamics, sea state, and sea ice by remote sensing from aircraft and satellites.

Marine Environmental Prediction Service for Water Pollution Control

DESCRIPTION OF SERVICE

The problems of water pollution are great, particularly in the coastal zone and the Great Lakes where man's activities have significant, immediate impact on environmental quality. These waters face serious prospects of environmental degradation unless some form of management, based on adequate monitoring and prediction services, is maintained.

MARINE ENVIRONMENTAL PREDICTION SERVICE FOR WATER POLLUTION CONTROL, BY AGENCY (in thousands of dollars)

	Operations		Relevant research		Total	
	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72
Commerce ...	405	495		660	405	1,155
Defense	6	9	652	1,083	658	1,092
Transportation	556	3,301	3,800	5,300	4,356	8,601
AEC			6,079	6,455	6,079	6,455
EPA	200	200 ¹	3,100	3,100 ¹	3,300	3,300 ¹
NASA			55	55	55	55
Total	1,167	4,005	13,686	16,653	14,853	20,658

¹ FY 72 projections for EPA are level-funding pending further deliberations by that Agency, which has been established only since December 1970.

Until the establishment of the Environmental Protection Agency (EPA), the principal water pollution control service was provided through the Water Quality Surveillance Program of the Federal Water Quality Administration (FWQA) of the Department of the Interior. As a provision of Executive Reorganization Plan 3, FWQA programs in pollution control were transferred to EPA. The Water Quality Surveillance Program of the Water Quality Office of EPA includes the collection of samples periodically from estuaries and the coastal zone. These samples are analyzed in regional laboratories and data are disseminated as required for implementing water quality standards, establish-

ing water quality baselines, and for supporting various planning and management programs.

The U.S. Geological Survey (USGS) of the Department of the Interior coordinates activities with the Water Quality Office of EPA to meet needs for basic data on water quality. Temperature, conductance, and common ions are generally measured at about 100 USGS stations to provide data to the Basic MAREP Service on streamflow into coastal waters. At a smaller number of these stations, turbidity, pH, nutrients, dissolved oxygen, coliforms, and biochemical oxygen demands are observed. There are 37 water-quality stations operated by the USGS in estuaries; and, at most of these, only temperature, conductance, common ions, and pH are being measured.

Selected Coast Guard vessels, equipped with salinity-temperature-depth (STD) sensors, are used in a variety of in-house and cooperative sampling programs for the analysis of water samples. Properties of coastal waters are sampled by fixed station sensors.

PLANS FOR SERVICE IMPROVEMENT OPERATIONAL PROGRAM

The Water Quality Surveillance Program of the Environmental Protection Agency (EPA) will be level-funded for FY 72 pending further deliberations by EPA, which has been established only since December 1970.

In FY 72, the Coast Guard will sponsor an expanded monitoring service in support of the MAREP Service for Water Pollution Control. The Coastal Zone Pollution Baselines and Monitoring Project will cost \$2,764,000 and will contribute significantly to the national quest for knowledge in this critical zone, making use of the multimission facilities of the Coast Guard that are located at over 100 coastal sites. Funds will be used to provide necessary instrumentation, operational personnel, equipment maintenance, and data dissemination.

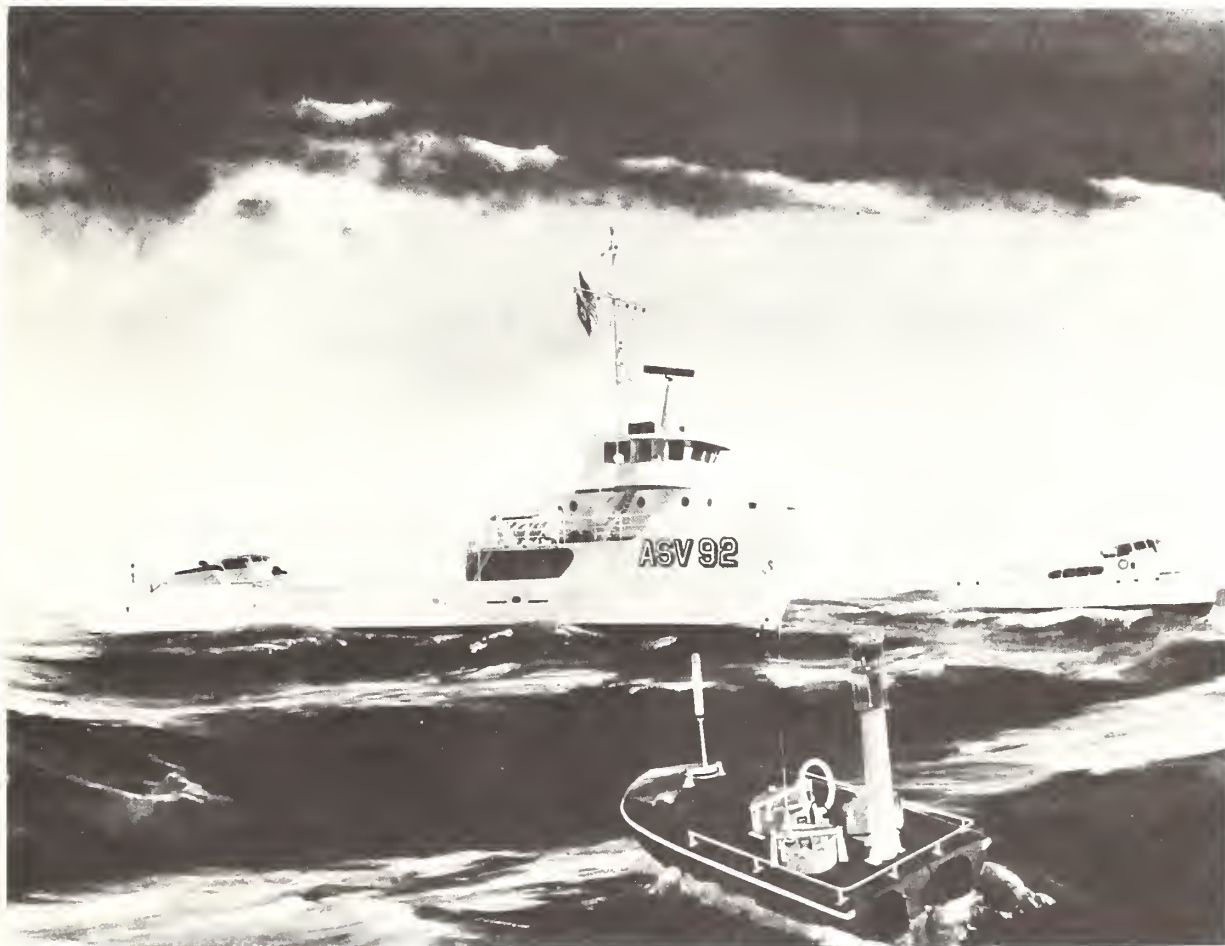
RELEVANT RESEARCH PROGRAM

Research and development activities which are

designed to contribute to the improvement of the MAREP Service for Water Pollution Control are or will be conducted by the Departments of Commerce, Defense, and Transportation and by the AEC, EPA, and NASA. Total funding in this category will be \$16,653,000 for FY 72, an increase of \$2,967,000 over the FY 71 amount.

The Department of Commerce will initiate research activities in estuaries and the coastal zone by \$660,000 in FY 72. Research projects of NOAA relating to improving this Specialized MAREP Service include estuarine flushing research, the physical processes occurring along the coastlines and in estuaries, and the dynamics and ecology of estuarine and coastal waters with respect to living resources. The National Ocean Survey (NOS) of NOAA is conducting a pilot study of the estuarine circulation in the Penobscot Bay of Maine as part of a study program to develop predictions of the flushing

rate of estuarine waters. A prediction model under development will be evaluated during FY 72 as part of the program for conducting circulation studies in other estuaries. Research leading to an understanding of the diverse physical processes that operate in the estuaries and coastal zone is being conducted by the Atlantic Oceanographic and Meteorological Laboratories (AOML) in Miami, Fla. A total of \$200,000 for this effort by AOML is planned for FY 72. The NMFS of NOAA will also conduct an active program in the dynamics and ecology of estuarine waters and living marine resources. This program, costing \$400,000 in FY 72, will acquire data for understanding the degree and consequences of pollution in the estuarine and associated waters over the continental shelf and to determine the effects on the living marine resources. Much of the field collection of data is to be accomplished in conjunction with and as a supplement to



Estuarine and Coastal Survey Vessel FERREL
(National Ocean Survey)

the MARMAP surveys as described in the next section on MAREP Service for Fisheries Interests.

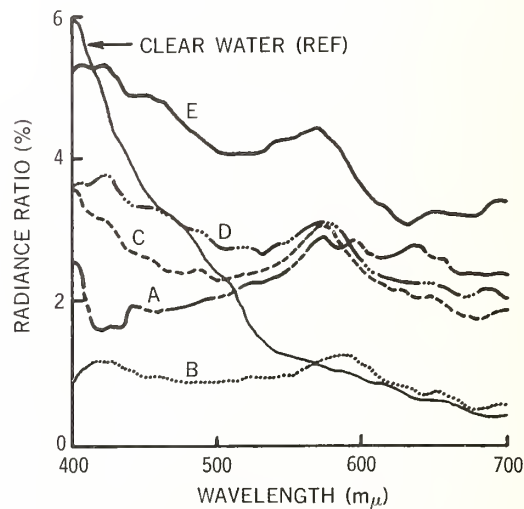
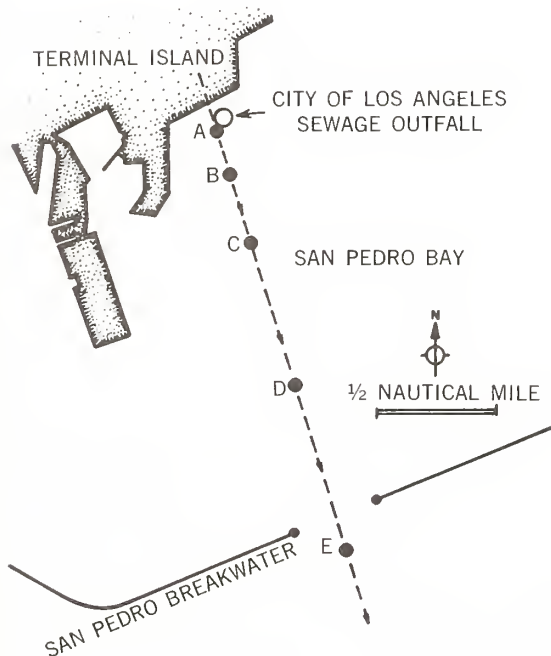
Though oriented toward military requirements, the Navy's Oceanographic Program contains resources and facilities to support the environmental pollution control study and conservation program of Defense; the potential to increase such support is present. Efforts in this program differ from most of the other reported Navy programs in that they are concerned primarily with the affected environment rather than with the source of pollution. Such efforts include environmental baseline surveys for "at sea" dumping, special fouling studies and atlases, shallow water surveys, remote sensing, diffusion studies, chemical studies, marine biological studies, thermal pollution studies, special flushing studies, and instrumentation development.

The Coast Guard will initiate a research program in FY 72 in support of a requirement to monitor pollution by hazardous materials. This effort costing \$900,000 will be directed toward the development of a national pollution response center and the provision for a rapid-response investigating team on hazardous materials.

Related to the MAREP Service for Water Pollution Control, the AEC supports research directed

toward the description of diffusion and advection processes in the estuarine, coastal, and pelagic realms and in the Great Lakes, and the influence of these processes on the time-space distribution of radionuclides and their pathways to man. Research is being supported on the effects of waste heat from nuclear power reactors in order to determine reliably the effect of heated effluents on the environment. During FY 72, research support by the AEC will be \$6,455,000, showing an increase of \$376,000 over the FY 71 level.

In addition, the AEC supports research conducted by other agencies as follows: the USGS of Interior is investigating the ultimate fate of radionuclides in the Columbia River estuary as part of a study being conducted to better predict the time-space distribution of radionuclides in estuaries that have large flows and turnovers of water; the Estuarine and Menhaden Research Center of the NMFS of NOAA is studying the cycling of trace elements in an estuarine environment, the energy relations in estuarine ecosystems, and the influence of environmental factors on the radiation response of estuarine organisms; the Sandy Hook Sport Fisheries Marine Laboratory of the NMFS is investigating sublethal effects of thermal additions



Spectrometric Radiance Curves for Various Pollution Concentrations Obtained by Remote Sensing (National Aeronautics and Space Administration and Naval Oceanographic Office)

on marine ecosystems, the effects of temperature and photo-period on fish spawning, and the effect of temperature on activity rhythms.

The Water Quality Office of EPA has projects in water quality control technology and in water quality requirements research that are intended to supply the description and prediction of the types, concentrations, and movements of pollutants in coastal waters and of the effects of pollutants on life.

Funding for this research in FY 71 amounted to \$3,100,000 and is level-funded for FY 72 pending further deliberation by EPA.

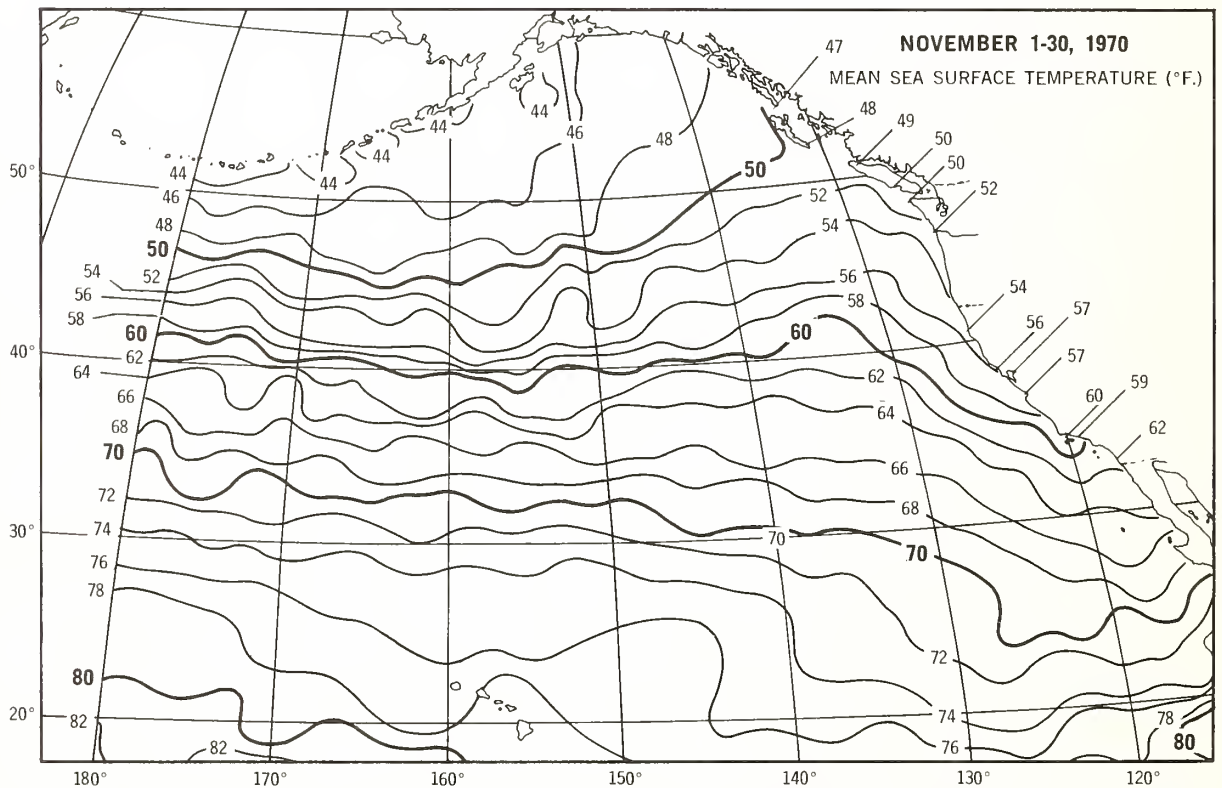
NASA supports two research projects related to improving MAREP Services for Water Pollution Control, both using remote-sensing techniques. One study is concerned with river effluents, and the other with observation of oil slicks, municipal sewage outflows, and sediment transport.

Marine Environmental Prediction Service for Fisheries Interests

DESCRIPTION OF SERVICE

Federal responsibility for providing a MAREP Service for Fisheries Interests, which involves the living marine resources and their environment, rests with the National Marine Fisheries Service (NMFS) of NOAA. Fishery biology predictions are of two kinds and may be categorized as tactical and strategic. The tactical predictions, issued on a close time schedule, deal with day-to-day and week-to-

week changes in the locations of fish concentrations and of the environmental conditions that influence fish movements. These predictions are principally of value to fishermen and fishery scientists during times when they are actually at sea. Tactical forecasts are exemplified by the Fishery Advisory Bulletins that are radioed daily to the albacore fleet in the eastern Pacific Ocean waters by the NMFS Fishery Oceanography Center in La Jolla, Calif.



Sea-Surface Temperature Chart for the North Eastern Pacific Ocean

MARINE ENVIRONMENTAL PREDICTION SERVICE FOR FISHERIES INTERESTS, BY AGENCY

(in thousands of dollars)

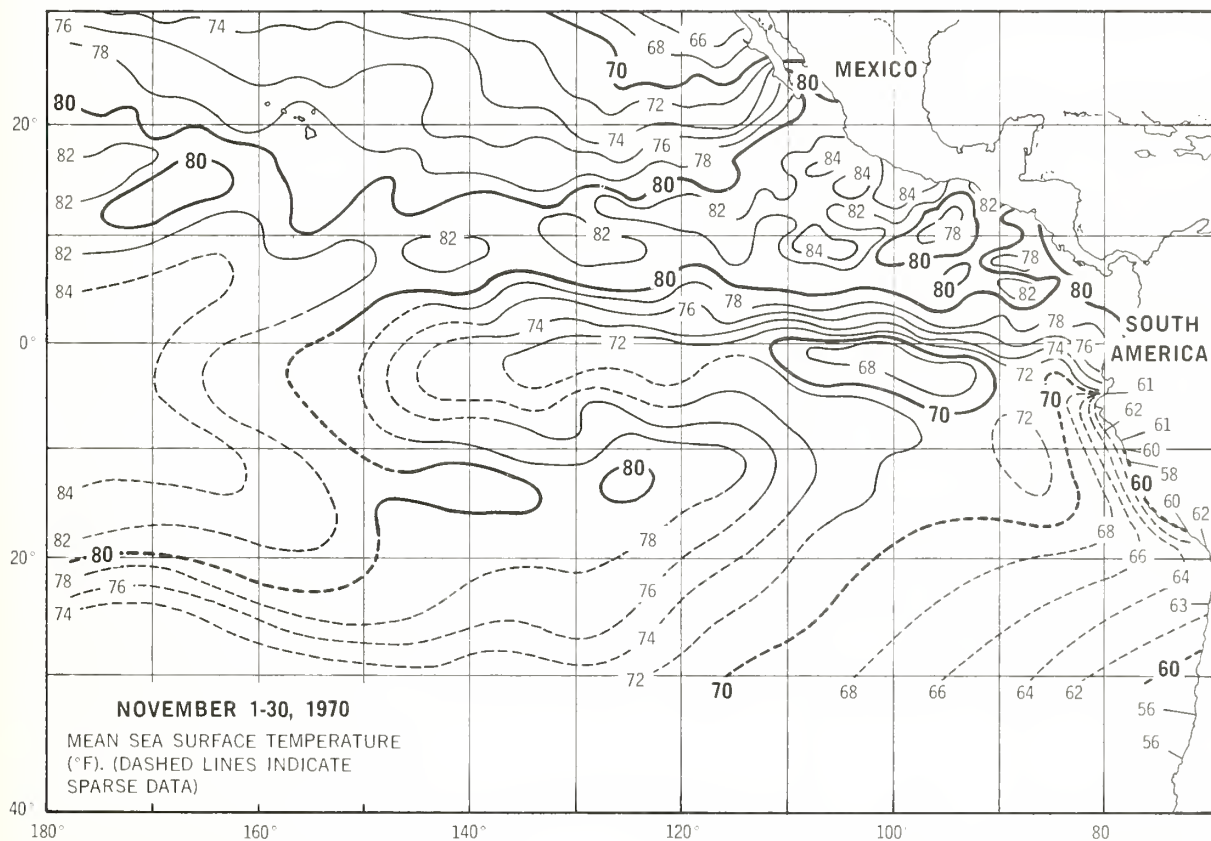
	Operations		Relevant research		Total	
	FY 71	FY 72	FY 71	FY 72	FY 71	FY 72
Commerce ..	4,147	5,147	6,911	8,211	11,058	13,358
Transportation	491	437			491	437
NASA			335	335	335	335
Total	4,638	5,584	7,246	8,546	11,884	14,130

The strategic predictions are designed to be valid for a longer term and deal with: (1) the abundances of year classes and populations of fishery species; and (2) the major changes in environmental conditions that influence the abundances and distributions of the species. The abundance forecasts are based primarily on survey cruises in

which a census is taken of a number of larval or juvenile fish. Strategic predictions are of fundamental importance for management and conservation of the fishery resources.

In addition, 15-day sea-surface temperature charts of the eastern Pacific Ocean are compiled from information supplied by the Navy, the Coast Guard, the National Weather Service (NWS), and by the fishing industry. These charts, now in the ninth year of publication, are distributed to assist fishermen in selecting optimum fishing areas. Examples of these charts are shown in the accompanying figures.

Strategic predictions by the NMFS, some in cooperation with international commissions and various States, are made of the abundances of shrimp in the Gulf of Mexico, on several ground-fish species and sea scallops off the New England coast, on menhaden off the U.S. east coast, on red and pink salmon and halibut in the Pacific Northwest fisheries area, on sardines off Baja California, on dungeness crabs off the California coast, and on skipjack tuna in Hawaiian waters.



Sea-Surface Temperature Chart for the Eastern Tropical Pacific Ocean

The NMFS advises the States, which receive Federal aid under Public Laws 88-309 and 89-304, in implementing various projects concerned with research, development, conservation, and management of commercial fishing resources, and also cooperates with the States and with international commissions in determining abundance and distribution forecasts of fish and shellfish stocks. Twelve major installations and 10 ships that are involved in coastal and offshore research are also employed in these activities.

The Coast Guard conducts monthly flights over the continental shelf off the east coast to record sea-surface temperatures and surface-swimming animals. A similar program is conducted by the Coast Guard on the west coast in cooperation with the Tiburon (Calif.) Sport Fisheries Marine Laboratory of NOAA. Charts of sea-surface temperatures are prepared and mailed monthly to fishermen, various institutions, and other potential users. Through its Oceanographic Unit, the Coast Guard conducts an environmental survey of the Northwest Atlantic fisheries area as a part of its coastal monitoring and studies effort. These surveys, funded at \$173,000 for FY 71, include Nansen and salinity-temperature-depth (STD) casts and analyses for inorganic nutrients.

The products, warnings, and other broadcast or published information of the Basic MAREP Service to fishing interests are also emphasized here. This information, although particularly important for the safety of lives and protection of property at sea, also aids fishermen in the judicious selection of areas where fish are likely to be concentrated and where the conditions of weather and sea state will permit efficient operations.

PLANS FOR SERVICE IMPROVEMENT OPERATIONAL PROGRAM

A major new initiative of the NMFS is the Marine Resource Monitoring and Assessment Program (MARMAP). The overall objectives of this Program are: (1) to assess and predict the abundance, geographic distribution, and harvesting or fish potential of the developed, developing, and undeveloped living marine resources; and (2) to describe and explain environmentally caused fluctuations in the abundance and distribution of these resources. Achieving these objectives will permit the determination of levels of use of these resources nationally and internationally. To achieve these objectives, it will be necessary to use data obtainable from other organizations, whenever possible, to:

- ☐ Conduct nationally coordinated surveys of living marine resources and to obtain suffi-

cient geographic and temporal detail for assessment and prediction purposes.

- ☐ Utilize environmental data from all appropriate sources, including and in conjunction with the living marine resource surveys, to understand the relation between the environment and the observed resource distribution and abundance.
- ☐ Develop a real-time system for acquisition, compilation, analysis, and dissemination of environmental data and information as it relates to resource species and their environment.

MARMAP will include three kinds of surveys concerning: (1) ichthyoplankton, (2) groundfish, and (3) pelagic fish. These differ principally in the method of sampling and techniques of data analysis; to a large extent, however, they can be carried out together by the same ships during the same cruises. Simultaneously with the biological sampling, a variety of physical and chemical variables of the environment will be measured. The surveys will be performed aboard ships of the NOAA fleet together with those of the Coast Guard, cooperating States, laboratories, and private organizations. Supplemental data will be obtained from buoys, satellites, and ships of opportunity. The surveys will be conducted at essentially three levels of sampling intensity with regard to time, space, and complexity:

- Broad-scale surveys (typically 3 per year), which will supply such information as: (1) disappearance or depletion of common species; (2) discovery of new species of potential resource value; and (3) disclosure of important changes in major oceanographic phenomena.
- Intermediate intensity surveys (4 to 5 in a year) are required to estimate the standing crops, limits of distribution, and reproductive seasons of principal resource species, as well as the major interactions with ecosystems. This level of effort will make it possible to evaluate those factors affecting resource species and the quality of the environment in limited regions of particular interest to the United States.
- The most intensive sampling (six or more surveys per year), is required where there are significant problems of fishery management, such as pollution or overfishing. This sampling level is designed to permit reliable assessment and prediction of the abundance and distribution of the resource species and of the important changes in the influence

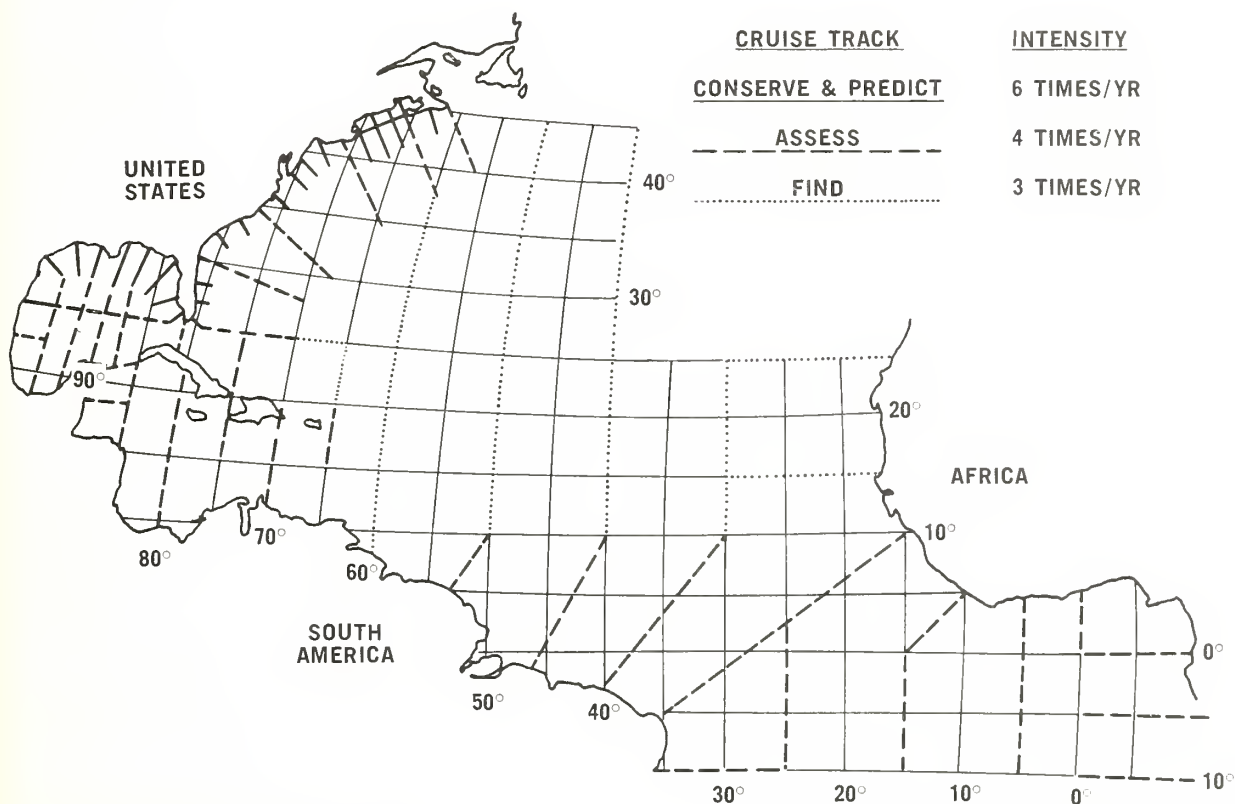
of the environment on these species.

The overall MARMAP service program in FY 72 will cost \$5,147,000 and will concentrate on: (1) the establishment of MARMAP operational control; (2) the development of detailed survey plans for the ichthyoplankton groundfish and pelagic fish surveys; (3) the initiation of a substantial portion of the ichthyoplankton survey; and (4) the development of a system to make full use of the diverse environmental data and information that is made available from numerous Federal, State, private, and international organizations. The technology thrust of MARMAP will fall broadly into three categories: (1) development of ship-based systems for monitoring the living marine resources and the environment; (2) development of aircraft- and satellite-based monitoring systems for similar use; and (3) development of information extraction systems.

Data acquisition activities planned in FY 72 for MARMAP involve the supporting of the species and environmental data acquisition phases of the ichthyoplankton surveys off the east and west coasts and developing operational plans for data acquisition at a total cost of \$1,150,000.

The accompanying chart indicates one of the areas selected and sampling intensity for MARMAP surveys.

As part of the MARMAP, the NMFS of NOAA plans in FY 72 to establish two environmental data groups to deal with oceanwide synthesis and analysis programs for the Atlantic and Pacific Oceans. These groups will reduce, edit, analyze, and distribute environmental data in order to correlate biological phenomena with the marine environment. Processing and analysis of biological specimens and environmental data to produce the needed information (or products) of the MARMAP is a large requirement at all the NMFS laboratories involved in the Program. This includes the sorting of planktonic fish eggs, planktonic larvae, and other planktonic animals; processing of specimens for detailed identification; analysis of data derived from specimens—for example, sizes and ages—and from remote sensing of resource species; and reduction, compilation, interrelation, analysis, and distribution of environmental data. At most of the NMFS Laboratories, the present scientific and technical personnel include the types of specialists needed for



Planned Cruise Tracks for MARMAP Survey 1
—Ichthyoplankton (National Marine Fisheries Service)

data processing and analysis in the various disciplines fundamental to the MARMAP. However, the overall number of these specialists is insufficient for the task, and they must be augmented by hiring additional staff in the NMFS Laboratories and by gaining the services of scientific and technical personnel in other Government agencies and private organizations through contractual and cooperative arrangements.

It is planned that MARMAP surveys will reach full operational status by 1975.

The National Environmental Satellite Service (NESS) of NOAA will assist the MARMAP by providing specialized environmental product support.

In addition to the MARMAP initiative, there are plans under the Basic MAREP Service to increase the number of expendable bathythermograph (XBT) observations from fishing vessels and from ships of opportunity in the Cooperative Merchant Ship Observational Program. These data will be used by the NMFS in its analyses and mathematical models relating fish concentration and distribution to ocean temperature conditions and will also contribute to the enhancement of the data base of the Basic MAREP Service.

RELEVANT RESEARCH PROGRAM

Research and development efforts which are rel-

evant to improving the MAREP Service for Fisheries Interests that support fishery management and fishing are sponsored by the Department of Commerce and by NASA.

Within Commerce, the NMFS supports studies of the dynamics of the ecosystems of oceanic, continental shelf, and estuarine waters and conducts studies of the environmental stress on fish habitats. NOAA also maintains a small environmental forecasting unit at the Navy's Fleet Numerical Weather Central (FNWC), Monterey, Calif., where NMFS scientists explore the applicability of oceanic and atmospheric information collected and analyzed at FNWC to fisheries research, development, and management.

As part of its Spacecraft Oceanography (SPOC) Project, NASA funds research projects totaling \$340,000 which are relevant to improving assessment and prediction of the living marine resources through the development of capabilities for data acquisition from space. These projects involve application of remote sensing techniques—including low light-level television, photographic imagery, spectrophotometry and spectroradiometry, and microwave radiometry—for the observation of such biological and physical phenomena as chlorophyll concentration, bioluminescence, fluorescence from fish scales and oil slicks, water color, upwelling, surface temperature, and surface currents.



Fisheries Research Vessel (National Marine Fisheries Service)

Marine Environmental Prediction Service for Mineral Exploration

DESCRIPTION OF SERVICE

There are no agency programs that are specifically directed toward the MAREP Service for Mineral Exploration, although most facets of the Basic MAREP Service are applicable. Of particular relevance to this Specialized Service are forecasts and warnings of tropical and extratropical storms, sea and swell, storm surges, tsunamis, ocean currents, and sea ice.

A unique specialized project of the Marine Minerals Technology Center (MMTC) of NOAA is described below.

PLANS FOR SERVICE IMPROVEMENT

RELEVANT RESEARCH PROGRAM

The Marine Minerals Technology Center (MMTC) of NOAA is conducting research with the objective of developing prediction techniques to assess the probable effects of marine mining on the environment. Such a capability will provide the technical foundation to establish guidelines for operational criteria and to recommend regulations for offshore mining. Current efforts involve primarily

the state-of-the-art studies and laboratory research aimed at the most fundamental aspect of the prediction problem—the effect of turbidity, as a result of mining, on marine life. An increase of \$200,000 in FY 72 will permit a limited expansion of laboratory experiments on the effect of mining on marine life to include the examination of major factors, other than turbidity, that must be considered in a marine mine environment. Studies will be conducted on the interaction to be expected with time in all three elements of a marine mine (material being mined, surrounding water mass, and marine life) for the most likely types of operations. Research will be started on developing preliminary dynamic simulation models for the prediction of this interaction over the economic life of the operating mines. The increase in funding will also permit the initiation of research to develop first-generation tools and techniques for characterizing the environment as a factor for correlation with the degree of disturbance to be expected from a mining operation.

Marine Environmental Prediction Service for Specialized Military Applications

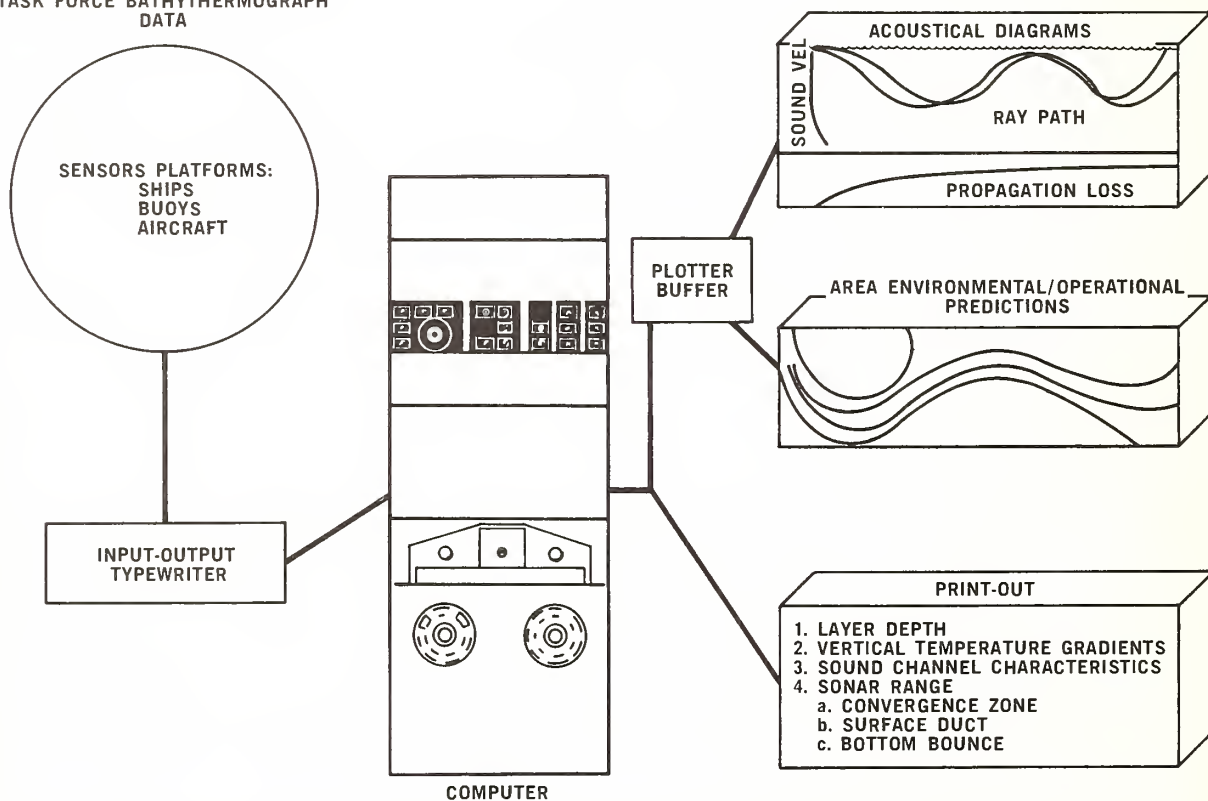
DESCRIPTION OF SERVICE

There are special requirements of the Department of Defense for a wide range of Marine Environmental Prediction (MAREP) Services which do not serve other user groups. The diversity and specialization of these Services is reflected in the many kinds of platforms, sensors, weapon systems, and vehicles operated by Defense throughout the total marine environment. Defense activities involving a need for specialized marine environmental knowl-

edge include search, rescue and salvage, antisubmarine warfare, amphibious operations, mine warfare, polar operations, and ocean and coastal engineering. In addition, routine fleet operations require a large volume of marine information and predictions not otherwise obtainable in the Basic MAREP Service.

Examples of marine environmental parameters forecast for special defense matters include: sea,

TASK FORCE BATHYTHERMOGRAPH DATA



Automated Shipboard Forecasting System (U.S. Navy)

surf, and swell; sea-surface temperature; thermocline depth; subsurface thermal structure; subsurface current vectors; special factors related to underwater sound; sea-ice cover; and optimum conditions for ship routing.

Much of Defense's effort in MAREP is applied in support of various antisubmarine warfare (ASW) systems. This is because the propagation of underwater sound is central to most aspects of ASW and the behavior of sound in sea water is strongly influenced by marine environmental factors. As more understanding is gained of the complexity and variability of the ocean, it is evident that the controlling environmental conditions must be monitored and projected into the future on a broad basis for ASW purposes.

In FY 71, Defense allocated \$17,420,000 for MAREP required for specialized military applications.

PLANS FOR SERVICE IMPROVEMENT OPERATIONAL PROGRAM

The FY 72 Defense budget for MAREP Service for Specialized Military Applications is \$17,899,000. Improvement of the specialized military service in FY 72 will be achieved by providing the most modern data acquisition equipment to additional naval ships, by providing temperature sensor support to new observation vessels, and by expanding computer facilities and support of oceanographic analysis and forecasting.

RELEVANT RESEARCH PROGRAM

Research directed toward improvement of the MAREP Service for Specialized Military Applications sponsored by Defense will total \$9,459,000 for FY 72; this amounts to a decrease of \$65,000 below FY 71. These funds support research and development in oceanographic processes, shallow ocean data, ice cover, large-scale air-sea interaction, internal sea motions, synoptic weather data collection, observational techniques from space, prediction techniques, automated thermal structure and wave forecasting, and telemetering buoy systems. The Navy's Ocean Science Research Program, a portion of which is devoted to MAREP, uses some 34 in-house laboratory and institution research vessels. Examples of relevant research efforts within the Navy are:

- ☐ The North Pacific Experiment (NORPAX), a large-scale air-sea interaction experiment aimed at a better understanding of the atmosphere and the upper few hundred meters of the ocean volume.
- ☐ The Automated Shipboard Forecasting System using real-time local water column and meteorological data and satellite data to update continuously the 24- to 48-hour forecasts of oceanographic conditions expected to be encountered by the ship.

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